THE

AMERICAN NATURALIST

VOL. XLI *July, 1907* No. 487

AGASSIZ CENTENNIAL

REMARKS OF

CHARLES WILLIAM ELIOT

LADIES and Gentlemen: Mr. Dana in opening this meeting spoke of the Saturday Club and of Agassiz as a member. His words reminded me of the only occasion when I ever heard a speech made at that Club. I have been a member of it now about thirty-five years, and only on this one occasion did I ever hear a speech made there. It was when Agassiz, who at that time always sat at the foot of the table, was going away on that long voyage of the Hassler round Cape Horn. At the head of the table sat Longfellow, as usual, and along the sides sat many of the men just mentioned by Mr. Dana. Near the close of the dinner Longfellow suddenly rose, and to our great astonishment said,— "Our dear friend Agassiz is going away; he is going on a long voyage in the hope of recovering his health; we shall miss him grievously; we shall welcome him back most thankfully, restored to health. Let us drink his health now." And we all got up except Agassiz, and drank his health; and then he rose and struggled to say something, and could not; and finally the tears rolled down his cheeks and he sat down speechless. It was a vivid instance of a characteristic quality in Agassiz, namely, the strength of his emotions. He was a man of strong and deep emotions, and his influence over us restrained, reserved Americans was largely due to the intensity of his feelings, and to the way in which his face and body expressed those feelings.

He was, as has been repeatedly said here this evening, a born

teacher and expositor. He expounded clearly and sympathetically before any audience the fundamental principles of his science, and gave examples illustrating the principles with both hands, and with shining, smiling face. He was just that,—a teacher by nature, an enthusiastic, earnest, moving teacher.

As Professor Gray has just said, he came into this Puritan society like a warm glow into a chilly room. He was a revolutionary spirit in Harvard College, an exception to all our rules. He welcomed special students, for instance, who could not possibly pass the examinations for admission to Harvard College. He kept them for years in his laboratory, training them in his observational method,—quite a new introduction among us. Many of our best people disapproved of that method! The son of one of our most distinguished surgeons submitted himself to the teaching of Agassiz in the crude zoölogical laboratory, and received several trilobites upon which he was expected to spend weeks,—examining them, seeing what he could discover in them, and making a record of his discoveries. He was kept at this sort of work for weeks without a book, and without plates. He was to make his own plates. At last the son described this process to the father as novel and interesting, but difficult. Now that father was at bottom a naturalist, like every physician or surgeon, and yet he said,—"What! no book, no plates, no guidance from the wisdom of all preceding generations! Set just to use your own senses on those fossils!" "Yes," said the son, "that was the whole of it." "Well," said the father, "that is exactly the way a puppy has to learn everything." The criticism was a real one; the father thought that Agassiz was neglecting all the natural and proper aids which past time had placed at the service of human youth.

And then, what a new kind of professor Agassiz was in this old town! He had none of the regular habits of the traditional Harvard professor. He did not even wear the characteristic black clothes. He would cross the College Yard any day of the week, at any hour of the day, in a soft, grey felt hat, smoking a cigar when to smoke in the College Yard was a grave offence. He never went to church. Sunday was his day of rest, but he did not take it in the New England fashion. His mode of lecturing was

unexampled among us. His conception of the duty of a professor to investigate, to discover, to collect, we had only noticed faintly in a few exceptional American teachers. Those methods had been introduced in small measure among us; but those were the prime ideas of Agassiz as a professor and a teacher.

There were but two pitiful little collections in the possession of the University when Agassiz first came here,— a collection of minerals, imperfect, small, and never properly arranged, and the beginnings of a botanic garden and herbarium. The idea of making great collections of natural history objects hardly existed among us; we had hardly aspired to such collections.

And then, he raised such astonishing sums of money for these new subjects of zoölogy and geology. A good deal of jealousy about this extraordinary money-raising was felt by members of other departments long established in Cambridge for the traditional subjects of collegiate instruction. I remember one night at my uncle Mr. George Ticknor's, hearing this jealousy expressed by one of Professor Agassiz's colleagues in Harvard University. But Mr. Ticknor said,— "Don't be alarmed; Agassiz will get more money out of the Commonwealth of Massachusetts for his subjects than any of you have dreamed of getting, than any of you could possibly get; but he will so equip his subject, he will set such a standard for collections in all subjects, that every department of learning in the University will profit by his achievements." That is just what has turned out to be the truth.

Agassiz founded here an institution; and he has had this unusual felicity,— that his son, an extraordinary naturalist and an extraordinary man of business, has built up with prodigious skill and liberality the institution which his father founded. That, I say, is a rare felicity.

Every teacher who is eminently successful as teacher, inspirer, and enthusiast, wins another sort of felicity in time. He brings up a group of disciples, and these disciples carry their master's teaching beyond their master's own range, and adapt his teachings to the new conditions which rapidly come about in science,— indeed, in all kinds of learning and working, and in modern society as a whole. That felicity Agassiz has enjoyed,— a beautiful felicity, a rare reward.

So we welcome this commemoration of a great teacher and a noble friend, and we say with Longfellow at the Saturday Club,—We miss him greatly, but we rejoice in his coming back to us in durable memory, and in the infinite ramifications of his personal influence.

CAMBRIDGE. 27 MAY '07

DESCRIPTION OF A NEW SPECIES OF TELENOMUS WITH OBSERVATIONS ON ITS HABITS AND LIFE HISTORY

A. W. MORRILL

MINUTE egg parasites belonging to the hymenopterous family Proctotrypidæ are known to play an important role in checking the multiplication of certain insects, fluctuations in the numbers of the parasites and hosts usually being intimately associated and resulting in a corresponding benefit or injury to the crops attacked by the latter. Notwithstanding the economic importance of the proctotrypids our knowledge of their life histories is very meager, and the incidental and more or less fragmentary notes upon which this contribution is based seem to point to a fruitful field for the investigator.

The data here presented were obtained in 1905 in connection with the investigation of heteropterous pests of cotton, alfalfa and other crops. The principal insect (Fig. 1, *a*) affected by the parasite here discussed, is a member of the stink-bug family or Pentatomidæ, and is commonly known in Mexico by the name "Conchuela." Only five North American species of proctotrypids known to attack the eggs of these bugs have heretofore been described, but many undescribed forms doubtless exist. All of these five species were described by Ashmead ('93), one belonging to the genus Telenomus and four to Trissolcus.

H. A. Morgan ('97) records that in Louisiana in August, 1896, the eggs of the Harlequin Cabbage Bug, *Murgantia histrionica*, were parasitized by proctotrypids (*Trissolcus murgantiæ* and *Trissolcus podisi*) to the extent of over 60%. The writer has noted ('07) that of 211 pentatomid eggs collected at Barstow, Texas, in September 1905, 148 or 70% produced adult specimens of *Telenomus ashmeadi*, the species hereafter described. During July 1905, 22 batches including 794 eggs were collected in cotton and alfalfa fields at Tlahualilo, Dgo., Mexico. Of these, 18 batches were parasitized and from their 638 eggs, 468 adult speci-

mens of *Telenomus ashmeadi* were produced. The remaining eggs, amounting to 27%, failed to produce adult parasites or to hatch; they were presumably destroyed by parasites which failed to mature or to emerge, for from the four non-parasitized egg batches 155 bug nymphs hatched from 156 eggs. In the case of every parasitized pentatomid egg batch collected at Barstow, Texas, or at Tlahualilo, Mexico, no nymphs hatched, showing that in the majority of cases complete destruction results whenever an egg batch of a host species is discovered by its tiny enemies. Of 41 batches collected, 36 or 88% were parasitized by *Telenomus ashmeadi*. This probably represents more closely

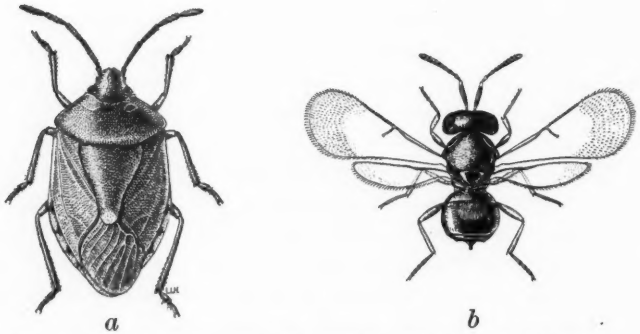


FIG. 1.—*a*, an adult conchuela, *Pentatoma ligata* Say, enlarged 2½ diameters. *b*, an adult female specimen of *Telenomus ashmeadi* N. Sp., enlarged about 20 diameters. From the author's illustrations in Bull. 64 of the Bur. of Ent., U. S. Dept. of Agriculture.

the economic usefulness of this species than do figures based upon the individual eggs. Although the multiplication of the host species appears to be effectively checked by these beneficial insects by midsummer, the pentatomid bugs affected have already had an opportunity to show the extent of their destructive capabilites. In the case of a large plantation in northern Mexico which comprises some twenty-seven thousand acres of cultivated land mostly devoted to cotton, the damage from the host species, the conchuela, is estimated at from twenty to sixty thousand dollars in single seasons. Without the natural check afforded by these parasites this destruction would doubtless be increased five or six times.

Description and Records of Breeding and Collection.

This parasite having been pronounced a new species of the genus Telenomus by Dr. W. H. Ashmead, the writer takes pleasure in dedicating it to this eminent authority on the parasitic Hymenoptera who has described more than 500 North American representatives of the family Proctotrypidæ.

Telenomus ashmeadi, N. Sp. ♀ (Fig. 1, *b*). Length 1.08–1.15 mm. Black with fine pale pubescence.

Head.— Width, .56 mm., scarcely wider than thorax, marked with impressed reticulations; mandibles black. Antennæ clothed with pale pubescence, dark brown to blackish in color, except pedicel the color of which gradually changes to light brown at distal end. Proportionate dimensions of antennal segments (Fig. 2, *B*) are as follows:[1]

	Scape	Pedicel	Segments of Flagellum									
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*1–9*
Length	105	28	30	18	12	11	17	15	15	16	20	124
Greatest width	16	12	11	11	13	15	18	18	17	16	13	—

Thorax.— Width .55 mm., length .48 mm. Dorsum marked with impressed reticulations, pubescent; mesoscutum rather roughly longitudinally grooved posteriorly; scutellum smooth and shining with a few pale hairs arising from minute punctures. Legs clothed with moderately dense pale pubescence; coxæ black; trochanters, tibiæ and tarsæ light brown by reflected light, yellowish brown by transmitted light; tarsal segments successively darker to the last; femora dark brown or brownish black by reflected light, dark brown by transmitted light. Proportionate length of segments of hind tarsæ not including tarsal claws, as follows:[2] $\frac{1}{13}$, $\frac{2}{6}$, $\frac{3}{4}$, $\frac{4}{3}$, $\frac{5}{4}$. Wings hyaline, iridescent; venation brownish; length of fore wing 1 mm., greatest width, .46 mm.

Abdomen.— Length .532 mm., width .518 mm.; basal two thirds of first segment striate above; basal two thirds of second

[1] Measurements made with 1 in. eye piece and $\frac{1}{8}$ in. obj.; tube length 160 mm. To obtain dimensions in mm. multiply by .003.

[2] Measurements made with 1 in. eye piece and $\frac{2}{3}$ in. obj., tube length 160 mm. To obtain true lengths in mm. multiply by .0148.

segment striate above except laterally, elsewhere smooth and shining; third to fifth segments punctate. Length of second segment .3 mm., greatest width .518 mm. Second, third and fourth segments fringed with sparse pale hairs posteriorly. Fifth segment finely pubescent. Ventral plates finely punctate and pubescent. Sheath of ovipositor about .044 mm. in length. Ovipositor when fully extended about .1 mm. in length.

♂.— Length .8–1.13 mm. Differs in form from the female principally in the moniliform twelve segmented antennæ and the more abruptly truncate abdomen. Head, .44–.62 mm. wide. Thorax, .38–.55 mm. wide. Length of abdomen .32–.44 mm., greatest width .38–.46 mm. Proportionate dimensions of antennal segments (Fig. 2, *A*) are as follows:[1]

	Scape	Pedicel	Segments of Flagellum									
	:	:	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*1–10*
Length	100	25	31	24	25	20	19	19	19	19	20	30	226
Greatest width	17	15	17	17	17	17	17	17	16	15	15	14	—

The constricted basal portion of the scape is dark brown; the outer three-fourths is light brown. Pedicel light brown, darker on outer side. Flagellum light brown basally, changing to dark brown distally. Legs except the coxæ light brown in color by reflected light, by transmitted light pale brown to honey yellow.

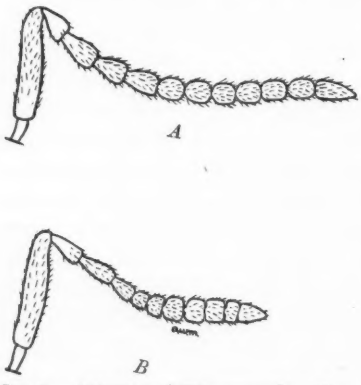


FIG. 2.— Antennae of *Telenomus ashmeadi*, enlarged 70 diameters. *A*, male. *B*, female.

Described from numerous specimens of both sexes. Cotypes deposited in the U. S. National Museum; Type No. 10364. Type locality Barstow, Texas; also collected at Tlahualilo, Dgo., Mexico.

[1] Measurements with same combination as used for measurements of the segments of the antennæ in the female. Multiplying the figures by .003 will give dimensions in mm. of average specimens bred from eggs of *Pentatoma ligata*.

All of the females were bred from eggs of *Pentatoma ligata* collected at Barstow, Texas, Sept. 12th, 1905. Three of the males were bred from eggs of *Thyanta custator* Fabr. In the foregoing description of the male, the smaller series of dimensions refers to the specimens bred from *Thyanta custator,* and the larger series of dimensions to specimens bred from the eggs of *Pentatoma ligata.* It is probable that this parasite will readily attack the eggs of most or all of the species of pentatomid bugs. In addition to the eggs of *Pentatoma ligata* they have been bred from the eggs of *Pentatoma sayi* Stål collected at Barstow and in the laboratory showed no hesitation in attacking the eggs of *Euschistus servus* Say and *Thyanta custator.* The size of the adult parasites corresponds directly with the size of the respective host eggs. The following table showing the relationship between the size of the host eggs and of the adult parasites is based on five male specimens bred from eggs of each of the three host species:

Host species	Pentatoma ligata	Euschistus servus	Thyanta custator
Host egg, average length	1.33	1.11	.90
" " , average diameter	1.01	.88	.75
Head of parasite, average width	.60	.53	.45
" " " , maximum width	.62	.54	.47
" " " , minimum width	.56	.52	.44

The parasitizing of eggs of pentatomid species representing more than one genus by a proctotrypid was recorded in 1897 by Prof. H. A. Morgan who bred *Trissolcus podisi* from the eggs of *Murgantia histrionica,* the Harlequin Cabbage Bug. The parasite in this case had previously been recorded as having been bred from the eggs of *Podisus maculiventris* Say (= *spinosus* Dal).

Habits and Life History.

Emergence of adults. The adult parasites use their mandibles to make exit holes for themselves at the top of the eggs, i. e., at the end through which the nymphs normally emerge (Fig. 3). When mature, the parasite completely fills the host egg and so far as observed always develops with its head at the end from which the pentatomid nymphs normally hatch. In one instance, one egg of a batch of 28 was deposited wrong side up by the parent

pentatomid (*P. ligata*) and after the batch was subsequently parasitized the adult proctotrypid emerged from the top side of the misplaced egg, *i. e.*, the under side of the egg batch.

Oviposition. On one occasion it was observed that four adult parasites, which had previously been rather quiet at the top of a cage, became very much excited immediately upon the introduction of empty egg shells of *Thyanta custator* and an unhatched egg batch of *Euschistus servus*. The insects were not ordinarily dis-

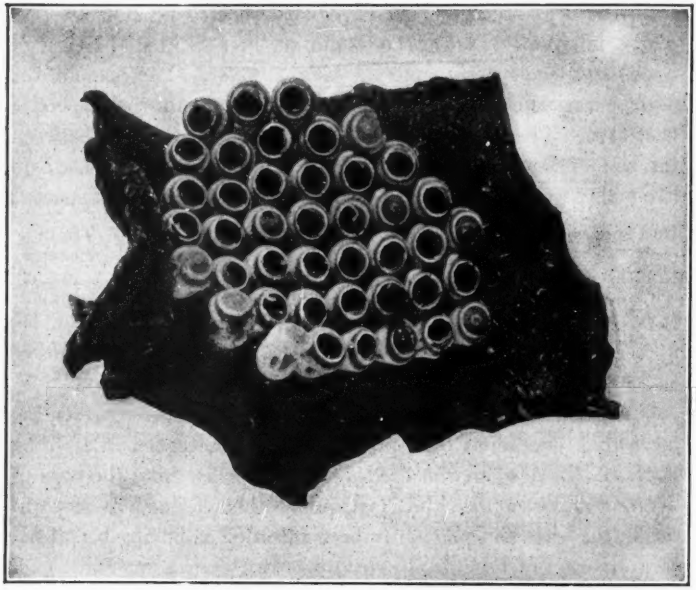


FIG. 3.— Egg batch of conchuela, *Pentatoma ligata*, from which 32 parasites, *Telenomus ashmeadi*, have emerged. Enlarged 6¾ diameters. The illustration shows three parasites, including male and female, ready to emerge; also an egg destroyed, probably by an ant. Morrill, Bull. 64 of the Bureau of Entomology, United States Department of Agriculture.

turbed by such a slight movement of the cage as was necessary to introduce these eggs and egg shells, but in this case they dropped almost at once to the bottom and carefully examined the empty egg shells, after which the eggs of *Euschistus servus* were found, and oviposition in these began almost immediately. At another time thirteen parasites, presumably all females, showed similar excitement upon the introduction of eggs of *Pentatoma ligata*.

No attempt was made to ascertain the nature of the tropism or sense which leads to the discovery of host eggs by the adult parasites, but it appears that the attraction is as great for empty egg shells of *Thyanta custator* as for unhatched eggs of *Euschistus servus* in a suitable stage of development for successful parasitism.

When the pentatomid egg batch is found, the adult parasite carefully examines it with her antennæ. If the eggs are satisfactory she sets to work industriously and oviposits in one egg after the other. The process of oviposition in a single host egg requires from two and one quarter to three minutes. The body of the female during this operation is held rigidly by the legs in a position nearly perpendicular to the surface of the host egg at the point of introduction of the ovipositor. The puncture may be made through the egg cap or top end of the egg, or it may be through the side of the egg. The latter is more frequently the case with eggs located on the outside of the batch.

Before leaving the egg the female scrapes it for a few seconds with the tip of the ovipositor, usually moving it around the point of insertion making a nearly complete circle, then reversing and with a shorter radius passing around to or beyond the starting point, then perhaps reversing again and with a still shorter radius making a nearly complete circle. Sometimes a much more irregular figure is traced but it is always curved for the most part, and so far as observed the direction of the movement is abruptly reversed from one to three times. It is difficult to imagine any useful purpose of this instinctive act except to mark the parasitized egg so that it can be detected as unsuitable for further attack by parasites of its own and probably other species.

Egg laying capacity. The largest number of pentatomid eggs positively known to have been successfully parasitized by a single female of the species here considered is 27. The total number of eggs which a female parasite may deposit appears not to be necessarily indicated by the number of adult parasites which may result. In many cases it has been found that the parasite for some reason failed to emerge even after reaching full maturity. In other cases the larvæ of the parasites appear to die when quite young, although accomplishing the destruction of the host egg. The data at hand on the number of eggs deposited by a single female parasite of this species are given in the following table:

NUMBER OF PENTATOMID EGGS PARASITIZED BY SINGLE SPECIMENS OF *Telenomus ashmeadi.*

Date 1905	No. of eggs accessible	No. of eggs from which adult parasites were bred	No. failing to hatch or to produce adult parasites; probably parasitized
July 17	28	27	1
" 28	42	21	7
Sept. 16	127	13	34
" 30	13	13	0
" 30	10	10	0
" 30	22	22	0

Developmental period of the parasite compared with the incubation period of the host. The parasite requires for its complete development about twice the normal incubation period of the host egg at any given temperature. The following table summarizes the data at hand which bear on this point:

DEVELOPMENTAL PERIOD OF PARASITES AND INCUBATION PERIOD OF EGGS OF THE HOST SPECIES.

When parasitized	Locality	Developmental period of parasite days.	hrs.	Aver. daily mean temperature °F	Incubation period of non-parasitized host eggs days.	hrs.
July 17, 6 P. M.	Tlahualilo, Mexico	10	23	80.2	5	1
Sept. 16, 10 A. M.	Dallas, Texas	11		76.	5	11
Sept. 24, 10 A. M.-5 P. M.	" "	11	12	74.	6	—
Sept. 28-29, 4 P. M.-4 P. M.	" "	15	—	—	–	—
Sept. 30, 4 P. M.	" "	14		69.8	7	6
Sept. 30-Oct. 1, 10 A. M.-4 P. M.	" "	14		—	–	–

In the case of the first, second and fifth records the exact time of the beginning of oviposition is given to the nearest hour. In the remaining records no note was made as to the exact time at which oviposition began. The last five records, although made at Dallas, Texas, refer to specimens of host and parasite originally from Barstow, Texas. The short incubation period in the record in Mexico as compared with subsequent records in Texas is probably due to the natural adaptation of the species to climatic conditions within its range. The parasite seems to be equally well adapted to its different environments inasmuch as the relation of its developmental stages to the normal incubation period of

the eggs of the host species remains quite constant as shown in the table.

Condition of host eggs necessary for successful parasitism. In the many cases in which definite records have been made, parasitism by *Telenomus ashmeadi* has been successful with the majority of the eggs of a batch up to the time that the embryos have gone through one half of their development. The failure to produce adult parasites from the remaining eggs in such cases is probably due to some other factor than the developmental condition of the host egg.

In one instance a batch of twenty-two eggs of *Pentatoma ligata* deposited on the morning of September 26th was parasitized by a female *Telenomus* on the morning of September 30th. The normal incubation period of the eggs of the host species at this season was about six and one half or seven days, the embryos therefore at the time of oviposition were slightly more than one half developed. Twenty-one of a total of twenty-two of the bug eggs hatched in a normal manner and the remaining egg failed to produce either a nymph or an adult parasite. A similar experiment with the eggs of *Euschistus servus* deposited four days previously and at a time when the normal incubation period was about seven days resulted in four eggs of a batch of ten producing adult parasites. The remaining six eggs contained parasites which failed to emerge, perhaps as a result of an attempt to delay their emergence by placing the egg batch for a few days in an ice box.

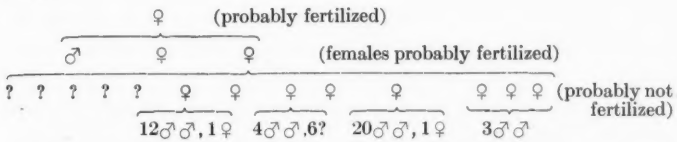
Changes in the appearance of parasitized eggs. During the course of two or three days following oviposition by the parasite the eggs of *Pentatoma ligata*, *Pentatoma sayi*, and *Thyanta custator* became slightly darker, but as they are subject to a variation in their color during normal development, parasitism cannot be said to produce any characteristic changes in appearance up to the time the adult parasites emerge. In the case of *Euschistus servus*, however, parasitism produces a marked change in color, since the egg membrane in this case is more translucent than with the other species mentioned, and the young nymphs are normally paler in color. Ten eggs of this host species were parasitized on October 1st, beginning at 3:00 P. M. On October 5th at 9:00 P. M. it was noted that seven of the ten were very dark in color, six being very dark gray and one slate gray; the three others had

changed color only slightly if at all. Two days later the eggs which had changed but little up to the time of the previous examination were as dark as the rest and indistinguishable from them as far as appearance was concerned. Parasites developed to maturity in each of these ten eggs and the first one was noted to have emerged at noon on October 16th.

Development in infertile host eggs. It is the writer's observation that shriveling of the eggs of pentatomid bugs indicates infertility although in some species, as in that of the Harlequin Cabbage Bug (*Murgantia histrionica*), a slight shrinking normally occurs just before hatching. With this as guide for the experiment, a batch of ten eggs was selected, which had been deposited by a specimen of *Euschistus servus* which previously had deposited a batch of infertile eggs. Four of these eggs were reserved as controls and a female parasite was given access to the remaining six; after having made the usual examination she was observed to begin oviposition. The four control eggs shrivelled in the course of a few days, but the six eggs into which the parasite had oviposited became dark in color and to all appearances promised to produce adult parasites. None appeared however nor did shrinking occur, and several weeks later when the eggs were opened their contents was found to consist of a very dark colored vitelline membrane together with a small shrivelled blackish mass on one side, which was unrecognizable as insect remains. A similar condition was found occasionally in parasitized eggs believed to be fertile and belonging to a batch from which many adult parasites appeared. The failure to produce adult parasites from the eggs used in the above experiment is therefore not positive evidence that this was due to infertility of the host eggs. The experiment shows however in a fairly conclusive manner that adult females of the species of proctotrypid here considered will readily parasitize infertile pentatomid eggs, and that the resulting larval parasites will develop sufficiently to cause the host eggs to take on the characteristic color of parasitized fertile eggs.

Parthenogenesis and its relation to sex of offspring. No absolute proof of parthenogenetic development of the eggs of *Telenomus ashmeadi* was obtained, but the contributary evidence from the few breeding experiments undertaken furnishes a good basis for the supposition that parthenogenetic development occurs and

moreover has a marked influence on the sex of the offspring. The following diagram shows the history of the offspring of a single female, which was one of a lot of 120 females and 19 males bred from eggs of pentatomids collected at Barstow, September 12, 1905:



The specimens recorded in the diagram by a "?" escaped or were otherwise lost so that their sex is unknown. The last generation included eighteen specimens which are not indicated in the diagram, since they came from eggs laid before the individuals of the preceding generation had been separated from one another. Of these eighteen, fourteen were males, and the others escaped before their sex had been determined. Two females bred to maturity in the laboratory under conditions which allowed of less doubt concerning their supposed infertility, oviposited in eggs of *Pentatoma ligata* and produced 27 and 21 adult parasites respectively; of these 17 and 15 respectively were males and the remainder escaped before their sex was determined. To summarize:— The offspring of the probably fertile females numbered 10 females, 1 male, and 5 undetermined; the offspring of the probably infertile females numbered 93 males, 2 females,[1] and 26 undetermined.

Proportion of sexes in nature. This subject furnishes additional and probably the strongest evidence that the fertility or infertility of the eggs of the parasite determines to a great extent the sex of the offspring. Sixteen females and 8 males were bred from a batch of eggs of *Pentatoma ligata* collected in a cotton field at Tlahualilo, in July, 1905. Another batch yielded 20 females and 2 males. Pentatomid eggs collected at Barstow in the months of August and September, 1905, produced 125 females and 19 males. In all, of 190 adult parasites bred from pentatomid eggs collected in the field, 161 or 85% were females, and 15% males.

[1] The writer has followed his original notes closely, although at present inclined to doubt that the two females referred to above were actually bred from the same egg batches with the males. Owing to their minute size and consequent difficulties met with in handling them it seems not impossible that the two specimens were in some way misplaced.

In the laboratory, where the chances of the females becoming fertilized were much less than in nature, the sex of 106 specimens was determined as above stated; of these 11 % were females and 89% males.

Longevity and Food Requirements. Under laboratory conditions, confined in glass tubes, pill boxes and insect cages, the adult parasites under observation had an average life of 3.8 days. The maximum longevity under these conditions was 8 days. The following table shows the various records in their relation to the season of the year:

LONGEVITY OF ADULTS OF *Telenomus ashmeadi* IN THE LABORATORY.

Period	No. of adult parasites	Approximate total no. of days lived	Average longevity per specimen
July 17–20	1	3	3
" 28–31	19	47	2.4
Sept. 14–16	1	2	2
" 27–Oct. 1	3	12	4
" 27– " 2	3	15	5
" 27– " 3	1	5.5	5.5
Oct. 5– " 13	38	165	4.3

An attempt to produce artificial hibernating conditions in an ice box was unsuccessful although the adult life of each of the 25 parasites used in the experiment was very much prolonged. When subjected to an average and only slightly varying temperature of 48.6° F., one adult lived 22 days, another 21 days, and the remainder between 12 and 20 days. At the temperature mentioned the adults appeared to be entirely inactive.

Adults of *Telenomus ashmeadi* have never been observed to feed. Those upon which the observations recorded in this paper were made had no access to anything that might have been used as food except pentatomid eggs and egg shells, fragments of more or less dried cotton leaves to which such egg batches were attached, and dry cotton lint or cloth which was used to close the tubes or cages in which the parasites were confined. No moisture was accessible to any of those which were used in the breeding experiments. In biting the exit holes from the host eggs the fragments of the egg shells are not eaten by the parasites. The evidence indicates that the parasites are sufficiently nourished

during their larval existence to require no food for carrying on, at least to a certain extent, their reproductive functions. It is not unlikely, however, that their longevity and reproductive capacity is increased by such food as they might obtain under natural conditions.

Summary and Conclusions.

1. A species of the proctotrypid genus Telenomus, believed to be new, is described under the name *Telenomus ashmeadi.*

2. The species, although originally bred from the eggs of pentatomid bugs of the genus Pentatoma, readily attacks the eggs of species of the genera Thyanta and Euschistus and such eggs ordinarily produce adult parasites differing in size from the parent in direct correspondence with the size of the host eggs.

3. The developing parasite invariably occupies a fixed position in relation to the embryo of the host, and emerges from the egg through the end from which the bug nymph normally hatches.

4. Adult female parasites are capable of detecting the presence of pentatomid eggs at some distance; four specimens were as strongly attracted by empty egg shells as by the unhatched eggs suitable for parasitizing.

5. Between two and three minutes are required for oviposition, after which the surface of the host egg is marked by the ovipositor in a characteristic manner, presumably for aiding in its subsequent detection as unsuitable for attack by other parasites.

6. The maximum number of pentatomid eggs known to have been successfully parasitized by a single specimen of *Telenomus ashmeadi* is 27; but there is evidence that this number may be greatly exceeded.

7. The entire developmental period of the proctotrypid parasite here considered is approximately twice the normal incubation period of the eggs of the host species, in Texas and northern Mexico during the summer months of 1905 varying approximately from 11 to 15 days.

8. Pentatomid eggs may be parasitized successfully by *Telenomus ashmeadi* up to the time that the host embryos have passed through one half of their incubation period. After this time the results are uncertain.

9. Pentatomid eggs with translucent membranes containing developing nymphs of a pale color undergo a characteristic darkening as a result of the parasitism. Other eggs with more opaque membranes and dark colored developing nymphs do not exhibit characteristic changes in external appearance.

10. Females of *Telenomus ashmeadi* show no hesitation in ovipositing in infertile pentatomid eggs, and such eggs when parasitized do not show the shrinkage which is usual in infertile eggs. In the case of *Euschistus servus* they undergo the changes in color characteristic of the parasitized fertile eggs of this species. Although no adults have thus far been bred from parasitized infertile eggs, the development of the parasite is at least partial, and the observations here recorded furnish only slight evidence that complete development in infertile host eggs is impossible.

11. Sex of the offspring seems to be controlled to a great extent, if not absolutely, by fertilization. In nature where the chance for a female parent to be fertilized is at a maximum the female sex greatly predominates, whereas under laboratory conditions which artificially reduce the chances for mating of the adults, the male sex predominates in an even greater proportion.

12. In confinement in the laboratory, adult life under ordinary temperature conditions lasts but a few days. The maximum period recorded during the month of July is three days, during September four days, and during October eight days.

13. The adults of *Telenomus ashmeadi* have not been observed to feed and apparently this is not necessary for carrying on reproductive functions.

WASHINGTON, D. C.

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THE DEVELOPMENT OF PINNATE LEAVES

FREDERIC T. LEWIS

BETWEEN 1837 and 1861 the development of leaves occasioned a lively controversy among botanists. Schleiden's school maintained that a leaf grows at its base,— not at its tip, and that this is the fundamental distinction between leaf and branch. Basal growth was demonstrated by painting the outer half of a young leaf and observing the diminishing proportion of the painted area as the leaf grew; it was also observed that many actively growing leaves of monocotyledons were dead and withered at their distal ends. The leaflets of compound leaves were thought to arise at the base and to be pushed outward so that the stipules and basal leaflets of the mature leaf were the last of all parts to appear. Contrary to all this Nägeli declared that the stipules are formed first, and that lateral leaflets are cut off from the terminal leaflet so that the apical lateral leaflets are the youngest. Since the basal part of the leaf forms first and grows longest it becomes the broadest part, but the growing tip remains slender. In 1861 Eichler introduced his thorough study of leaf development with the statement, "The nature and development of leaves have been a subject of controversy among botanists until recent times, and the issue is still undecided." Since then, however, the attention of investigators has been directed chiefly to newer problems, and the subject remains about as Eichler left it. Ten years ago, quite unaware of this controversy, the writer gathered and sketched a selection of mature rose, blackberry, and sumac leaves which presented the problem in very clear terms. In the present paper some of these leaves are to be described, after which the embryological interpretation of their peculiarities will be considered, and finally their evolutionary significance will be noted.

Mature Leaves.— The group of rose leaves (Fig. 1) was gathered from different bushes and from various parts of the stem. Although they all probably came from *Rosa lucida* Ehrh., other species of wild rose may be included. The arrangement of the leaves is

purely arbitrary, but it indicates a possible mode of development. The lower pair of leaflets in *b* is close to the stipules; in *c* and *d* the length of petiole separating them from the stipules is successively greater. In *e* one stipule is enlarged and leaf-like at its tip, having a coarsely serrate upper margin and containing a mid-rib; in *f* there is a complete leaflet close to the stipule. *G*, *h* and *i* show an imperfectly developed pair of leaflets in relation with the stipules. *J* and *k* have a perfect pair close to the stipules, and in *l* and *m* this third pair is more distally placed since the petiole is longer. Thus the series suggests that the third pair of leaflets is developed from the outer portion of the stipules. Forms showing the similar addition of a fourth pair of leaflets may easily be obtained, together with those which present the first and second pairs in relation with the stipules. In the leaf *a* there is an unpaired fourth leaflet on the right, but the stipule on the left is distinctly longer than its mate.

From the examination of mature rose leaves it appears, therefore, that leaflets are added from the stipules. It would be inferred that the basal leaflets are the last to develop, but that the stipules arise before the first pair of lateral leaflets. In the rose neither the terminal nor the basal leaflets show lobation or other evidence of leaflet production.

In the "high-bush" blackberry, *Rubus sp.?*, there is a different process of leaflet formation as shown in Figure 2. *A* is a simple leaf with stipules. In *b*, *c*, and *d*, by the lobation of the basal portion of the leaf blade, the first pair of leaflets is produced. The stipules are not involved in their formation. In *e*, *f*, *g* and *h*, a second pair of leaflets appears by the lobation of the basal leaflets. Thus the mature blackberry leaves suggest that leaflets arise, not from the stipules, but from the basal leaflets.

The sumac, *Rhus copallina* L., presents a third type as seen in Figure 3. The leaf *a* has five pairs of leaflets together with an undivided terminal leaflet; *b*, *c*, and *d* also have five pairs, but the terminal leaflet is lobed or divided and suggests the origin of the sixth pair of leaflets shown in *e*. In the sumac the addition of new leaflets is from the terminal leaflet, and never from the basal as in the blackberry. There are no stipules.

Leaves of the sumac type are generally called *basifugal* (Goebel

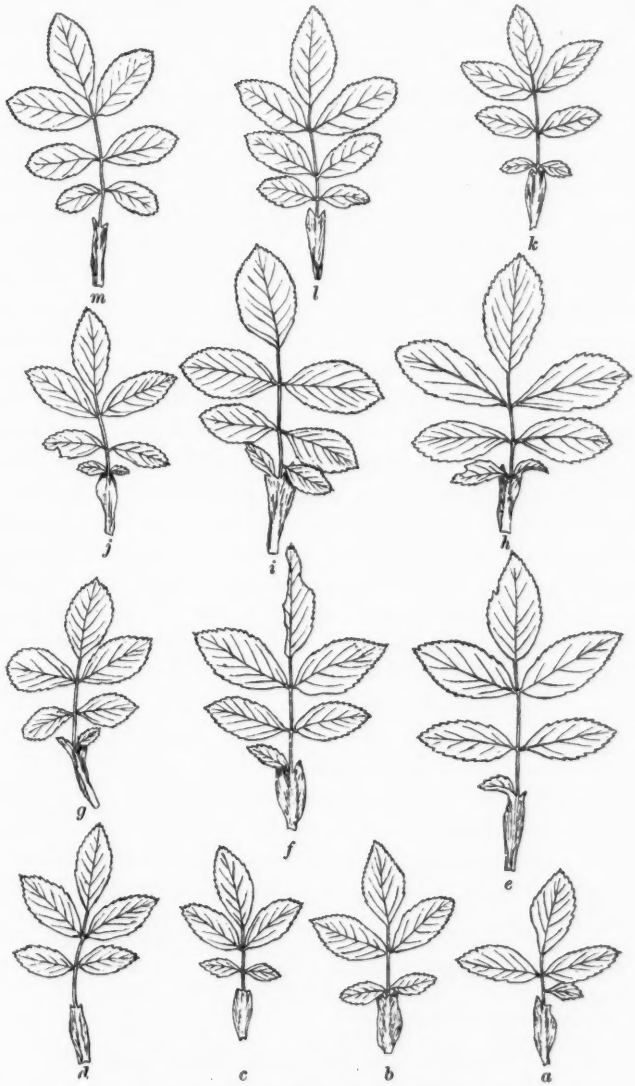

FIG. 1.— Leaves of the wild rose, *Rosa lucida*, Ehrh. ½ natural size.

prefers akropetal). Nägeli who believed that all leaves grew near their apices, studied particularly the leaf development in *Aralia spinosa* L. which is of the basifugal type.[1] At the distal ends of its chief subdivisions there are lobed leaflets like those of the sumac. Steinheil[2] who believed that leaf-growth was generally basal, considered that compound leaves were an exception in that their outermost leaflets were the youngest. Trécul[3] recognized both the basifugal type of compound leaf and the *basipetal* which would include both the blackberry and rose. He distinguished also a *mixed* and a *parallel* type. These are discussed and rearranged by Eichler[4] (pp. 16–21). In addition to basifugal and basipetal he recognizes six types, namely divergent, convergent, simultaneous, ternary, cyclical, and parallel (but the last is not in Trécul's sense). In the divergent form, the leaflets develop from the center toward both ends of the leaf; in convergent leaves they develop from both ends toward the center; and in the simultaneous type all the leaflets arise at one time. When a single leaflet divides to make three, the distinction between basifugal and basipetal can scarcely be made since the next pair of leaflets may arise from the terminal leaflet as in the sumac, or from the basal leaflets as in the blackberry; but these ternary leaves are usually counted as basipetal. Cyclical leaves may be either basipetal or basifugal; the two lateral basal portions of the blade become connected around the petiole in peltate form, as in Ricinus, Lupinus and others. In the parallel type, on both sides of the median line vertical divisions arise, parallel with the periphery of the leaf. This occurs in Foeniculum and others. In the parallel form the divisions may be basipetal or basifugal. Eichler states (p. 18) that "Other developmental types have never been observed either by me or by earlier investigators; but considering the manifold forms of leaf development doubtless other types exist."

[1] Nägeli, C. Wachsthumsgeschichte des Blattes von Aralia spinosa Lin. *Pflanzenphysiologische Untersuchungen*, Heft 1, Zürich, 1855.

[2] Steinheil, Ad. Observations sur le mode d'accroissement des feuilles. *Ann. des Sci. Nat., Partie Bot.*, 1837, ser. 2, vol. 8, pp. 257–307.

[3] Trécul, A. Mémoire sur la formation des feuilles. *Ann. des Sci. Nat., Partie Bot.*, 1853, ser. 3, vol. 20, pp. 235–314.

[4] Eichler, A. W. Zur Entwickelungsgeschichte des Blattes. Marburg, 1861, 60 pp.

In Eichler's tables *Rhus typhina* is with the basifugal leaves; "*Rosa canina, tomentosa, arvensis,* etc." are with the basipetal.

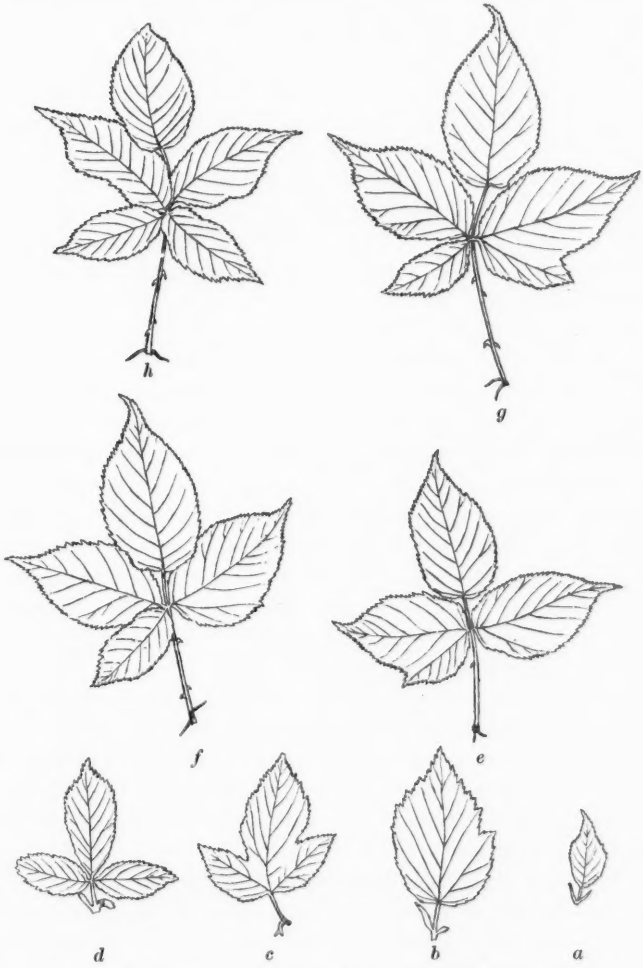

FIG. 2.— Leaves of the high bush blackberry, *Rubus sp.?* ½ natural size.

Rubus is not included, but the similar Potentilla is classed with the rose. Goebel[1] likewise places "all digitate leaves" with the

[1] Goebel, K. Organographie der Pflanzen. Part 2, Heft 2, Jena, 1900.

rose and calls them basipetal (p. 525). There are two serious objections to grouping the rose leaf with that of the blackberry or potentilla. Neither the terminal nor the basal leaflets of the rose are ever lobed to produce new leaflets as in the blackberry; and in the blackberry the stipules are not involved in leaflet production as in the rose. If the term basipetal is to be retained for the blackberry and potentilla type, the leaf formation in the rose may be described as *stipular*.

Embryonic Leaves.— The interpretation of series of leaves such as those shown in Figures 1–3 depends upon the study of their embryonic development, for they are mature leaves and can never add to their lobes or leaflets. The number of these parts is determined before the leaf expands.

According to Eichler (*loc. cit.*) a leaf may begin in two ways. In some cases, immediately below the tip of the axis, there arises simultaneously in all its parts, a wall-like proliferation of cambial tissue corresponding to the entire insertion of the future leaf together with its stipules, if it is to have any. In other cases, beneath the growing tip of the axis a low papilla or conical proliferation appears, which quickly spreads laterally so that more and more of the circumference of the stem is involved in the leaf formation. This spreading ends before the leaf begins to be subdivided into lobes. In one of these two ways the *primordial leaf* is formed, from which (and never from the stem) all parts of the mature leaf develop. They are not pushed out from the stem. The primordial leaf forms from the stem; after that, all growth of the leaf is only an elaboration of the primordial leaf.

After its formation, the primordial leaf begins to differentiate a stationary basal zone, which is concerned only with the formation of stipules, and a vegetative outer zone which produces the petiole and blade. Petiole formation always follows blade formation; the expansion is at least indicated before the stalk begins. In palmate and pinnate leaves all of the main subdivisions are generally mapped out before the appearance of the petiole. The mid-rib may be present before the blade expands, as is true especially of simple, feather-veined leaves and some compound, pinnate forms; or the expansion of the blade is primary and the formation of the chief veins secondary, as in many three-parted, pinnate, and palmate leaves.

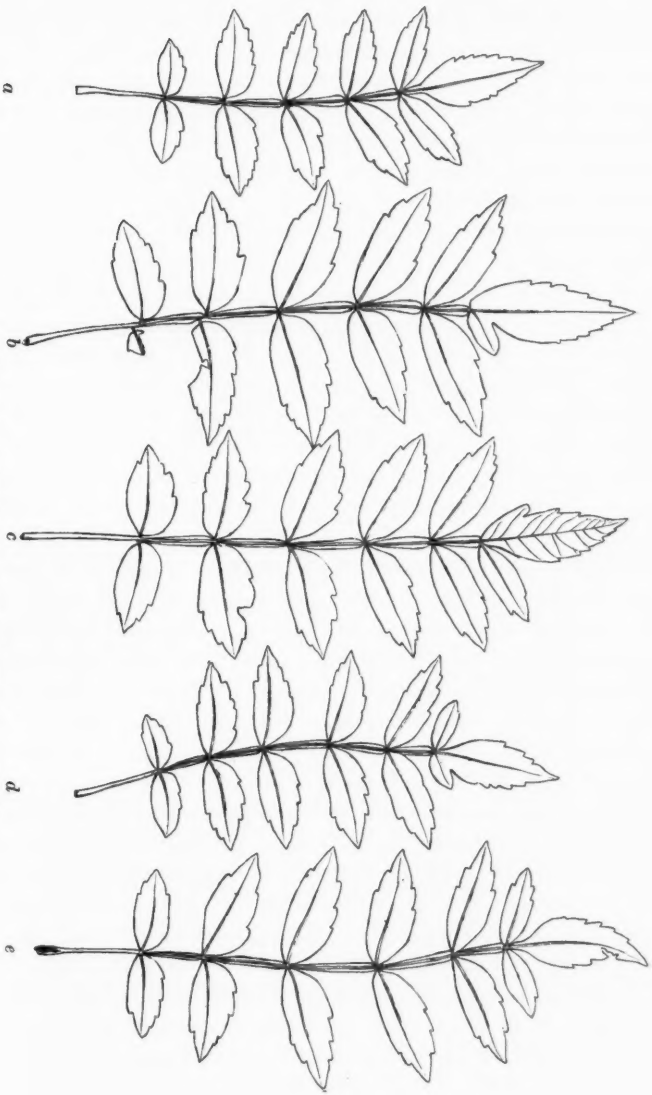

Fig. 3.— Leaves of the dwarf sumac, *Rhus copallina* L. ½ natural size.

The development of a leaf to this point is characterized by segmentation of its parts, accompanied by relatively little increase in volume. This is its *embryonic stage*. It is followed by the *stage of expansion* in which there is a great increase in volume without the addition of lobes or leaflets. The recognition of these two fundamental stages in leaf development is essential in interpreting mature leaves.

The embryonic development of the rose leaf is shown in Figure 4 *a*, *b*, and *c*. *A* is from Sir John Lubbock's drawing of the growing point, with side views of two primordial leaves in successive stages of development. He states[1] that the leaf "commences as a small knob at the side of, and immediately below the growing-point. When this knob has reached a certain length it presents two lobes (as on the left of the drawing)..... The lower lobe is one of the stipules, which according to Schacht appear first.... The stipule appears almost simultaneously with the first and upper leaflet, before any of the lower and later ones. These originate close above the stipules." On the right of Figure 4 *a*, the leaf presents lower lobes for the stipules, middle lobes for a pair of leaflets, and an upper lobe for the terminal leaflet. If by an arrest of development the stage of expansion should begin at this time, we should expect such a mature leaf as in Fig. 4 *d*. Expansion at the younger stage shown in *a* would produce a leaf like *e*; and at a still earlier stage, when the primordial leaf was but slightly indented, the stipules and blade would be scarcely separable, as in *f*.

Later stages in the embryonic development of the rose leaf are presented in *b* and *c*, after Trécul. They show the addition of the second and third pairs of leaflets respectively. It may be noted that in Eichler's opinion Trécul was misled by the early large size of the stipules into believing that they formed before the leaflets. Eichler finds that in various types of leaves the stipules may arise either as the first or the last of the primary divisions of the leaf blade, or at some intermediate time. In the rose they form last (*loc. cit.* pp. 26–27). If this were true, however, one might expect to find certain mature leaves without stipules, but such do not occur. The fact that if a mature leaf shows only

[1] Lubbock, J. On Buds and Stipules. London, 1899, 233 pp.

two divisions they will be terminal leaflet and stipules is in harmony with the early origin of the stipules as stated by Trécul and Lubbock.

The embryology of a basifugal leaf is shown in Fig. 4 *g*. Since drawings of the sumac are not available, Trécul's figure of *Gleditschia ferox* has been substituted. The youngest leaf, *l'*, is without lobes; in the older leaf, *l''*, the stipules (*s*) have appeared; and in the oldest leaf a succession of leaflets is forming from the base

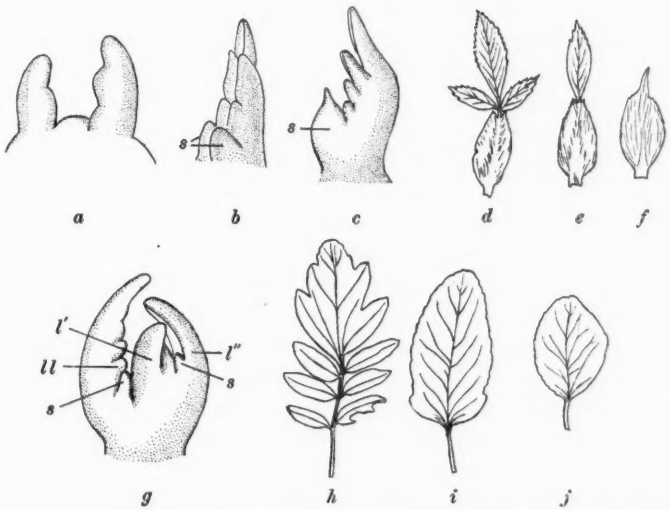

FIG. 4.— Embryonic leaves, and mature leaves showing an arrest of embryonic development. *a*, *b*, and *c*, embryonic rose leaves, *a* after Lubbock, *b* and *c* after Trécul. *d*, *e*, and *f*, mature rose leaves. *g*, embryonic leaves of *Gleditschia ferox*, after Trécul. *h*, *i*, and *j*, mature leaves of *Gleditschia triacanthos*. The embryonic leaves are considerably magnified; the mature leaves are reduced.

toward the apex (the lowest leaflet is marked *ll*). An arrest of development at this stage may produce such a leaf as *h*. The forms *i* and *j* may be compared with *l''*. In mature leaves of *Gleditschia triacanthos* the stipules, if retained, are very small and they do not appear in those figured.

From the consideration of the embryology of rose and honey locust leaves it appears that the developmental history may be

approximately inferred from the variations in mature leaves. The study of the mature leaves is therefore significant, but it ought to be confirmed by embryological examinations.

Evolutionary Significance.— A knowledge of leaf development is of great importance to the paleontologist, and in a paper entitled "Localized Stages in Development in Plants and Animals" Jackson presents a study of mature leaves from a geological and evolutionary point of view.[1] His conclusions are stated to be in the direct line and the natural outcome of Hyatt's principles of development. Professor Jackson's work upon leaves was continued by Cushman who published three papers on localized stages in this journal.[2] The leaves at either end of a branch which terminates in a flower are well known to be simpler than those along its middle portion. Simple leaves are expected near the bud scales, the sepals, and the cotyledons. St. Hilaire (quoted by Trécul) sought to explain this arrangement by nutritive conditions; the simple leaves in the young plant or near the flower are due to weakness and exhaustion. In full vigor leaves tend to become compound, and there are some instances in which cultivation in rich soil has favored the production of compound leaves. This explanation is not satisfactory, however, and Jackson proposes another. The early leaves are said to represent the adult types of ancestral forms; and the successive leaves between the cotyledons and the most complex forms which the plant produces record the evolutionary history of the species. The simplification of leaves toward the flower is considered a senile repetition, in reverse order, of the developmental series. In localized parts of the adult, as at the base of vigorous shoots, stages of leaf development may be found similar to those of young plants; their equivalents are to be sought in the adults of ancestral groups.

The nature of ancestral forms is for the geologist to decide; it

[1] Jackson, R. T. Localized Stages in Development in Plants and Animals. *Mem. of the Boston Soc. of Nat. Hist.*, 1899, vol. 5, no. 4, pp. 89–153.

[2] Cushman, J. A. Studies of Localized Stages of Growth in Some Common New England Plants. *Amer. Nat.*, 1902, vol. 36, pp. 865–885.

Studies of Localized Stages in Some Plants of the Botanic Gardens of Harvard University. *Amer. Nat.*, 1903, vol. 37, pp. 243–259.

Localized Stages in Common Roadside Plants. *Amer. Nat.*, 1904, vol. 38, pp. 819–832.

is generally assumed that their leaves were simpler in outline than those of existing species. If, however, it is true that the plant is recording its history in producing these simpler leaves, the reason why they occur in the places named remains as much a mystery as ever. The plant just before producing a flower can scarcely be regarded as weak, exhausted, or senile. The embryologist is content to find that the diverse forms of mature leaves arise from papillae which become characteristically lobed and molded before they expand. If expansion occurs before the modelling is complete, a simple form of leaf results. A more accurate account of the development of the papillae in various plants ought, however, to be obtained.

Summary.

Certain features of leaf development which were established some fifty years ago, should not be overlooked. These are primarily the basipetal and basifugal types of growth, which may be verified by collecting mature leaves, and which can profitably be taught to students of elementary botany.

Among the basipetal leaves of the earlier writers there are two radically different types, represented by the rose and blackberry respectively. The rose should be separated from this class and its leaf development may be described as *stipular*. Mature leaves indicate that the rose stipules are formed before the lateral leaflets, as observed by Trécul and Lubbock but denied by Eichler.

The formation of relatively simple leaves in plants which bear lobed or compound forms may be described embryologically, as an arrest of development in the primordial leaf followed by a stage of expansion, or by expansion before the embryological stage has been completed. Rapidity of growth may account for the constant location of the simpler leaves near the cotyledons, bud scales and sepals.

Cambridge, Mass.

CONTRIBUTIONS TO THE PLEISTOCENE FLORA OF CANADA

D. P. PENHALLOW

EARLY in the present year I received from Professor A. P. Coleman of Toronto University, a very fine collection of leaves from the Interglacial deposits of the Don Valley, Toronto. With them there was one small but rather well preserved fragment of a woody branch which it was possible to identify with accuracy. These specimens prove to be important since they serve to confirm in rather striking ways, conclusions already reached through previous studies of the Don material, and they furthermore afford additional evidence bearing upon the preglacial existence of types now unknown in the living state. It is therefore thought desirable to place on record such facts as are revealed by a study of this collection.

The last previous record of the Don plants was made by me in 1904 ('04) when thirteen species were passed in review. Since then both Berry ('06) and Hollick ('06) have added to our knowledge of the Pleistocene of Virginia and Maryland, and the evidence they bring forward goes to show that essentially the same flora characterized the entire region between Virginia and Ontario in Pleistocene time. The following species are included in the present studies:—

Acer pleistocenicum Penh.— This species appears for the fourth time in collections from the Don Valley, and in the present instance it forms a large percentage of the entire material. Most of the specimens are in fragments, but one or two are nearly perfect. One of the best of these is reproduced here on a diminished scale (Fig. 1), as it is more complete than that employed for the original description ('90, 327).

In the last enumeration of Canadian Pleistocene plants ('04, 72), attention was directed to the very close resemblance between *Acer pleistocenicum* Penh., and *A. lesquereuxii* Knowlton ('98) and the opinion was then expressed that the two are undoubtedly the

same. With the possibilities arising from more extended comparison of material representing a wider range of variations, the conviction becomes stronger that the opinion so stated is a tenable one.

Acer torontoniensis n. sp.— The Don collection embraces a number of specimens, some of them fairly perfect, representing a species of maple altogether unknown, either in the fossil or the living state. This leaf appears to present two principal variations which depend in part upon the relative depths of the principal sinuses and the character of the minor lobes or teeth, but chiefly upon the fact that in one form the base of the leaf is only slightly if at all lobed, while in the other case two large lobes extend downward from the insertion of the blade on the petiole and enclose the latter. Two principal veins extend from the base of the midrib to the corresponding principal lobes, and two subordinate veins of varying prominence extend diagonally downward from near the same point, into the two minor and variable lobes which form the base of the leaf blade. From this description, as also from the two specimens shown in Fig. 2 it will be seen that this leaf belongs to the same group with our common hard maples. Comparison with these latter also shows that its nearest representative among existing species is the common rock or sugar maple, *Acer saccharinum* Wang. Comparing the upper fossil of Fig. 2 with one of the more ordinary types of leaf of the sugar maple, it appears that the chief points of difference are to be found in the form of the sinuses and in the character of the large teeth or smaller lobes. If again we compare the lower fossil leaf in Fig. 2 with the corresponding type of leaf of the sugar maple, the resemblance becomes much stronger by reason of the similar basal lobes, which have unfortunately been much broken away in the fossil. The differences noted are such as might well result from changes incident to natural development, whereby the more simple tends in the direction of the more compound, and when to this there are joined the actual resemblances, they suggest a very intimate relation between the existing sugar maple and the fossil, of such a character as to indicate that the latter may be the ancestral form of the former.

A comparison of leaves of the sugar maple with those of the

Norway maple will show that although they differ materially with respect to venation, they resemble one another in a very remarkable manner as to the form of the sinuses and the detailed configuration of the lobes. These resemblances between two such well defined species, are precisely of the same order as those which are recognized in a comparison of the fossil with the sugar maple. It therefore becomes obvious that in the absence of flowers and fruit, it is not possible to effect a satisfactory specific differentiation

FIG. 1. *Acer pleistocenicum* Penh. ×0.55.

on the basis of leaf form only, but upon this basis the form now under discussion must be regarded as altogether different from any previously recognized fossil or recent species. The diagnosis of this leaf may be stated as follows:—

Leaves strongly and palmately veined; two principal veins arising at the base of the midrib and traversing the principal lobes; two inferior veins of varying prominence arising from near the same position but extending diagonally downward into the inferior lobes. Leaves three to five lobed; the two basal lobes variable,

sometimes small and inconspicuous, or prominent and extending downward so as to enclose the petiole as in Acer saccharinum Wang.; the sinuses broad and shallow; the terminal lobe with two large, lateral teeth; the lateral lobes with one or two large teeth on the lower side; the teeth acute, rarely somewhat acuminate toward the summit.

Hollick ('06, 234) has recently observed the occurrence of maple fruits in the Pleistocene of Maryland, but it is at present impossible to connect them definitely with any of the recognized leaves or wood so far studied.

Carya alba Nutt.— Although never abundant, the leaves of the hickory have been noted in three former collections from the Don. Their form and venation are so characteristic as to leave little room for doubt as to their true character.

Hollick ('06, 221, 222) now records the occurrence of three species, one from the Talbot and two from the Sunderland Formation of Maryland. Only one of these is specifically recognizable, and to this the name *Hicoria pseudo-glabra*, Hollick, is assigned.

Cercis canadensis L.— The red-bud, an altogether new constituent of the Don flora, is represented in the present collection by a few leaf fragments which are nevertheless sufficient to establish the identity of the species.

Cyperus sp.— Fragments of jointed stems showing a finely striated surface are referable to the genus Cyperus without specific differentiation. Such fragments are of common occurrence in material from the Pleistocene, and they possess little or no significance with respect to a knowledge of climatic conditions.

Gleditschia donensis n. sp.— One or two leaflets are clearly comparable with those of the genus Gleditschia to which they are referred under the name of *G. donensis*.

The genus is at present represented in North America by two species ('02, 76) of which the common three-thorned acacia, *G. triacanthos*, seems to be more nearly related to the fossil, and presents the closer resemblance with respect to geographical location.

Maclura aurantiaca Nutt.— One imperfect leaf is referable to the osage orange. Although not now growing in the same region,

this species has been recorded on previous occasions as occurring in the Don deposits of which it is a recognized feature.

Picea nigra Link.— This species is a constant constituent of the Don flora and has been recognized in nearly all previous collec-

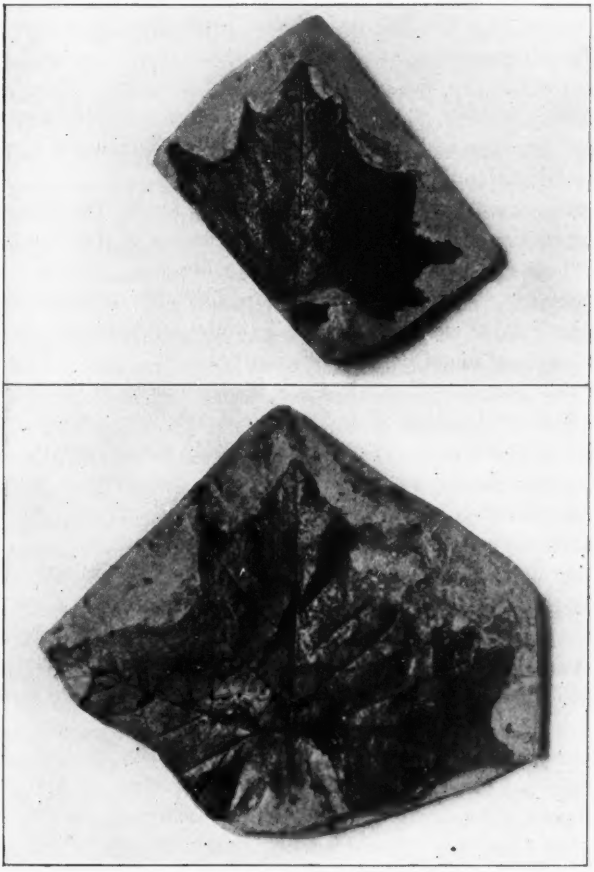

FIG. 2. *Acer torontoniensis* n. sp. × 0.55.

tions. As now, it is always represented by fragments of wood, usually small branches in a more or less altered condition.

Ostrya virginica Willd.— Although not recorded as embraced in

any previous collection from the Don, the leaves contained in the present one are sufficiently characteristic to make the determination reliable.

Platanus occidentalis L.— One small and imperfect leaf shows the characteristic venation of the sycamore. Although not often represented, this tree has nevertheless been found in a previous collection representing two localities, and it is a recognized constituent of the Don flora.

Hollick ('06, 231, 232) has shown the occurrence of *P. aceroides* Goepp., together with another large leaved but unnamed species, in the Sunderland Formation of Maryland.

Populus grandidentata Michx.— This well known but sparingly represented species is a well recognized element of the Don flora, and it once more appears in the present collection.

Prunus sp.— The genus is represented in the present instance by a single drupe of an oblong form. A similar but somewhat shorter fruit has been found on one previous occasion.

Quercus alba L.— The white oak is represented in the present collection by fragmented but well characterized leaves. This species has been observed previously in only one collection. The specimens obtained from Gaol Hill were so imperfect as to make the determination open to some question, but the present material is sufficiently perfect to remove all doubt.

Other oak leaves are also embraced in the 1906 collection, but the fragments are too incomplete to justify reference to a particular species. It is quite probable that they may represent the white oak, but this cannot be stated with any degree of certainty since the Don flora embraces no less than seven recognized species, any one of which they may be.

Under the name of *Quercus pseudo-alba*, Hollick ('06, 227) describes an oak from the Sunderland Formation of Maryland. The leaves which he figures bear a very close resemblance to those from the Don, and it is not unlikely that they may be the same, but a close comparison of more perfect specimens should be made before final decision is reached.

Robinia pseudacacia L.— A few leaflets of the common locust are found in the present collection. This species appears to be rather sparingly represented in the Don flora, since this is only the second time it has been found.

According to Hollick ('06, 234) this species occurs in the Talbot Formation of Maryland, and the leaflets figured by him are identical with those from the Don.

Tilia americana L.— The exceedingly well characterized leaves of the common linden or basswood, occur in the present collection in rather large numbers, some of them being fairly perfect. The species is sparingly represented in the Don Pleistocene, since it has been recognized in only one other collection.

A recent note by E. W. Berry, ('07, 80) directs attention to the occurrence of either *T. americana* or *T. heterophylla* in the Pleistocene clays at Fish House, New Jersey. The imperfect condition of the fossils makes it impossible to determine their correlation with one of the existing species, and in this emergency the specific name *T. dubium* originally assigned by Newberry to the leaves, is now retained but transferred from the genus Tilliæphyllum, and the citation therefore becomes *Tilia dubia* (Newb.) Berry.

Ulmus americana L.— The common American or white elm has been identified on former occasions as a prominent constituent of the Don flora, and it is once more represented in the present collection from the same locality.

Lesquereux ('83, pl. LIV, f. 10) has figured under the name of *U. pseudo-americana,* a specimen from the John Day Basin of Oregon (Upper Miocene) which very closely resembles the existing species and may well be regarded as its progenitor.

In a report upon Tertiary plants from the region of the International Boundary in British Columbia, collected by Prof. R. A. Daly in connection with the International Boundary Commission, and now in course of publication, certain elms are described on the basis of their wood structure, and it is seen that they differ but little from some existing species. Among them there is one which differs from the wood of the white elm to about the same extent that the leaf of *U. speciosa* Newb. differs from its more modern representative, *U. americana.* In a collection of woods from the Pleistocene of Elmira, N. Y., now being studied, either this or a closely related species is found, and the evidence therefore tends to show that Ulmus americana may be definitely traced back into Miocene time.

Ulmus pseudo-racemosa Hollick, has been found by Hollick in the Sunderland Formation of Maryland ('06, 228), and this

gives one more proof of the wide extension of the same flora, since the Elmira woods contain an elm which will be designated as *U. proto-racemosa.*

BIOLOGICAL CONSIDERATIONS

The present determinations lend emphasis to previous conclusions respecting the character of the Don flora, its relation to existing vegetation in the same region, and its indications of the existence of a climate warmer than at present and comparable with that of the middle and southern United States.

With four exceptions, Ostrya, Gleditschia, Cercis and *Acer torontoniensis,* the flora indicated by the present studies is identical with that previously determined to be characteristic of the Don Period or Warm Climate Period of the Pleistocene. But an examination of these four new elements, shows that they also, are quite consistent factors in the warm climate flora.

Gleditschia triacanthos L. which is undoubtedly the nearest living representative of the fossil, finds its northern limit of distribution according to Macoun ('83), in Ontario, and it occurs on the sand dunes of Pelee Point to which the seeds appear to have been carried across the Lake from Ohio. But according to Sargent ('02, III, 75) this species appears on the western slope of the Alleghany Mountains whence it extends westward as far as longitude 96°, and southward to Alabama, Mississippi and the Brazos River in Texas, from which it would appear that it is distinctly characteristic of a climate warmer than that now known in the region of Toronto, and comparable with that of the Don Period in Pleistocene time.

Cercis canadensis is practically unknown in Canada, although Britton ('97, II, 257) records it as occurring in southern Ontario. Sargent on the other hand ('02, III) gives its northern limit as New Jersey, whence it extends southward to Tampa Bay and westward to the Brazos River in Texas. The evidence which it affords of a warm climate is even more conclusive than in the previous case.

Ostrya virginica ranges from Cape Breton westward through the Valley of the St. Lawrence to Lake of the Woods and Rat Portage, northern Minnesota and the Black Hills of Dakota, and southward to northern Florida and eastern Texas. Although the tree is very common throughout all this region, Sargent ('02,

IX, 35) states that it is most abundant and of largest size in southern Arkansas and adjacent parts of Texas. It is therefore evident that in spite of its wide distribution and high northern range, it is essentially a southern type, and the evidence it affords is therefore in direct accord with that offered by those other representatives of the Don flora now recognized for the first time.

With respect to *Acer pleistocenicum*, very little of a definite character can be said since we know nothing of it except through its occurrence in the Don clays; but its very definite association with a warm climate flora leads to the conclusion that it also must bear the same relations to meteorological conditions, and that it must of necessity be a southern type.

Acer torontoniensis is similarly unknown beyond the Don clays, but the same evidence which applies to *A. pleistocenicum* must lead to similar conclusions with respect to its climatic relations. If this species is to be regarded as the actual progenitor of the sugar maple, it is perhaps somewhat difficult to explain satisfactorily how a southern type, or at least a type with a far southern extension, can have become so altered as to constitute an exclusively northern type, since the converse would be susceptible of a more ready explanation. If on the contrary, this be regarded as a distinct species with adaptation to a more southern climate, it becomes quite easy to understand how it was obliterated from the Toronto region by the southward movement of the ice sheet, in precisely the same manner that other species were driven out of the same area and ultimately confined to more southern localities.

The present studies serve to give renewed emphasis to the idea which has now passed beyond the limits of a working hypothesis, that successive northerly and southerly movements of the continental ice sheet, involving corresponding movements in vegetation, were productive not merely of plant migrations from north to south and *vice versa*, but that they established conditions which permanently eliminated those species which, we may suppose, occupied a somewhat unstable position in the flora and were therefore susceptible to a relatively slight change of surroundings. This conception is in exact accord with the present status of the genus Sequoia which, from a very wide distribution extending over the entire northern half of the continent as far as Alaska and Greenland, has become restricted to a very limited area on the

western slopes of the Sierra Nevada Mountains where, according to Gray ('89, II, 147) the two species now occupy an unstable position of such character that "a little further drying of the climate would precipitate their doom."

The evidence afforded by the Pleistocene clays of Toronto is therefore in accord, in this respect, with that furnished by certain Pleistocene deposits at Elmira, New York, and by the conclusions elsewhere stated with respect to the recession of Sequoia, Taxodium, and probably also Pseudotsuga, from the present Great Plains region of Saskatchewan and Alberta ('04, 64–65).

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THE SIGNIFICANT RESULTS OF A DECADE'S STUDY OF THE TUNICATA

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In any mass of detailed knowledge of organic phenomena, there is sure to be something of general significance for philosophical biology. Under the guidance of this principle I have tried to skim the cream from the results of the last ten years' researches on the Tunicata. These skimmings I present under the following captions:— 1, Taxonomy and Affinities; 2, Distribution; 3, Morphology; 4, Embryology; 5, Physiology.

1. **Taxonomy and Affinities.**— There are several questions of general interest that naturally arise under this head. The Tunicata being a comparatively small class of animals, does the progress made in getting hold of he new kinds indicate that we are approaching completeness in this direction? The class being as thoroughly pelagic at one extreme of its habitat, as thoroughly littoral at another, and as thoroughly abyssal at still another as any class of animals, what is being revealed as to the dependence of number of kinds upon environment? Is the progress of knowledge bringing out anything conclusive as to the greater success of certain types of organization over others because of better adaptation to environment?

Herdman's "Revised Classification of the Tunicata," published in 1891, contains a total of 538 species. This list supposedly includes all the species known at that time. By a reasonably careful enumeration, those described since that year number 521, making a total of 1069 species now known. The better explored portions of the sea, such as the Atlantic about the British Islands, the coasts of Continental Europe, and the Mediterannean, have yielded very few of the new ones, probably not more than half a dozen. The regions that have contributed most are the Australian waters (Herdman and Sluiter); the seas traversed by the Siboga Expedition (Sluiter); the Ceylon region (Herdman); the southern South American region (Michelsen); the Japanese coasts (Oka and Hartmeyer); the Pacific North American region (Ritter);

the west African coast (Sluiter); the Arctic (Hartmeyer); the Antarctic (Sluiter and Herdman); the western tropical Atlantic (Sluiter and Van Name); and the western central Pacific (Sluiter).

As regards the sedentary Tunicata the general statement seems justifiable that *every portion of the sea at moderate depths, when first invaded by the collector, yields a considerable number of new species.* The further conclusion seems warranted that a few more decades of exploration, as active as the last three or four have been, would put us in sight of nearly the whole existing tunicate fauna so far as the open sea and shallower waters are concerned. Experience seems to indicate that here as perhaps in other branches of systematic natural history, after a particular locality has been explored with reasonable care, further collecting does not greatly alter the total number of recognized species. The new ones later brought to light are approximately offset by the elimination of spurious ones from the earlier lists. The slaughter of supposed species of Botryllus by Bancroft should be noted in this connection. Almost certainly the same sort of thing would happen in several other genera, were they to be studied with equal care. This suggestion relative to the rounding out of knowledge of the number of kinds of living tunicates does not touch the question of how in the future it may be found best to classify them.

As to the deployment of the species with respect to the extremes of habitat, of the 521 described since 1892 only about 40 are pelagic. Of these, 10 belong to the Thaliacea, 27 to the Larvacea, and the others to the Pyrosomæ. This is the result in spite of the fact that exploration has been prosecuted little if at all less vigorously in the pelagic than in the littoral realm. This is surely true as regards the Thaliacea and the Pyrosomæ. As to the Larvacea, the minuteness of the animals and difficulty of handling them results in their receiving somewhat less attention than the other groups. There can be no doubt that the living pelagic tunicates are much less abundant in kinds than the sedentary ones. Is this due to the fact that they are subject to less diversity of environment? This explanation is not of necessity the only one. It is possible that the small number of kinds is due to the fact that the group is waning or senescent. I am inclined to think a good case could be made for this hypothesis, at least as regards the Thalia-

cea. It is by no means impossible that could paleontology give its testimony on the history of this group, as it does for the Cephalopoda and the Foraminifera, for instance it might reveal a richness of ancestral kinds far greater than that presented by the modern fauna.

A matter of prime interest from its bearing on the problem of fitness to survive is the large number of kinds (species?) belonging to a few of the genera, or sets of illy separated genera, of sedentary ascidians. The most conspicuous groups from this standpoint are 1 Ascidia; 2, Molgula; 3, Cynthia with its close ally Rhabdocynthia; 4, Styela with the scarcely distinguishable Polycarpa; 5, Botryllus and its close congener Botrylloides; 6, Amaroucium with its near relative Aplidium; and 7, Leptoclinum. These seven groups contain more than 600 of the approximately 1000 species of simple and compound ascidians now described. There are recognized at least 80 genera in these two tunicate sections. In other words, as our scheme of classification now stands less than 14% of the genera contain fully 60% of all the species. It will be observed that these few prolific groups present all the leading types of sedentary ascidian organization. An analysis of the species in these groups with reference to the character of their environments would certainly not show that some of the types tend to be restricted to one set of external conditions while others are restricted to different conditions. *I do not believe there is anything in our present knowledge of ascidian structure, function, or distribution, to warrant the conclusion that the groups most abundant in kinds are so because of their greater fitness to survive, or their relative adaptability to external conditions.*

Little headway has been made toward determining the extrinsic affinities of tunicates. Indeed although nothing has turned up to shake confidence in their chordate nature, some of the newer results are puzzling rather than enlightening. Thus Goldschmidt reports the embryology of Appendicularia (strictly Oikopleura) to be so similar to that of the typical ascidian that little hope can be entertained of further light on the problem from this direction. He confirms the contention of Seeliger and others that there is no real metamerism in the tail of this animal. I have examined a number of stages in the larval life of a species of Oiko-

pleura and am able so far to testify to the correctness of Goldschmidt's observations. On the other hand Metcalf finds some evidence of metamerism in the rapheal nerve of the Molgulidæ. Perhaps these facts slightly support Perrier's view that the adult sedentary simple ascidian is nearest to the vertebrate ancestor and that consequently Appendicularia is a modified ascidian larva.

Seeliger and Metcalf doubt that there is a true homology between the tunicate and vertebrate hypophysis. Neither does Seeliger believe the vertebrate thyroid to be related genetically to the tunicate endostyle.

Largely from the character of the stigmata and the absence of an epicardium, Julin holds a Mediterannean species called by him *Archiascidia* to be the most primitive ascidian.

As to intra-class kinships, perhaps nothing of greater general interest has come to light during the decade than that Octacnemus is an ascidian proper and has nothing to do with the Salpidæ. Metcalf and Ritter have made this positive.

The polyphyletic character of the compound ascidians is now admitted by probably all students of the class.

2. **Distribution.**— Some of the most interesting questions under this head are presented by the abyssal fauna. We now know at least 25 species that belong here and about half of these come from depths of 2000 fathoms, more or less. Some of the genera represented in this deep-sea fauna, though widely separated systematically, still present a common trait in the tendency to retrogression of the branchial apparatus. This is distinctly seen in genera so far asunder as Culeolus, Octacnemus, and Hypobythius. On the other hand species of familiar littoral genera are coming up from time to time from great depths, having no marks whatever that can be regarded as impressed upon them by their peculiar environment. For example I have now in manuscript the description of a Styela from 2200 fathoms off the California coast, which does not differ from several shore species more than these latter differ from one another; neither do its specific marks betray anything of the peculiarities of its habitat. No aspect of observational as contrasted with experimental natural history promises more light on the nature of species, so it seems to me, than do faunas of the profound ocean depths.

The cosmopolitanism of some of the pelagic species, notably *Salpa runcinata fusiformis*, is significant. It appears as if there is no part of any sea in which this animal does not flourish. Perhaps the data yet in hand do not warrant quite so sweeping a statement, but it is borne out by material now in my possession from many parts of the Pacific, and by already published data from other oceans. This Salpa is a close rival of some species of Sagitta and of *Eucalanus finmarkicus* in this regard.

We now have sufficient information about Arctic ascidians (Bonnevie, Kiear, Huitfeldt-Kas, Hartmeyer), and about those of the Antarctic (Herdman, Sluiter), to make it clear that this group lends little support to the "bipolar" theory of distribution. Fifteen years ago Herdman concluded that sedentary tunicates are more numerous in species, and are in general of larger size in higher latitudes than in the tropics and subtropics. In spite of some rather rich collections recently described from tropical waters, notably from Bermuda and the East Indies, it seems as though the generalization will stand. My own somewhat extensive experience with Pacific Ocean ascidian faunas appears to support it.

3. **Morphology.**— Knowledge of the adult anatomy of the group has been enriched in many directions. The structure of the appendicularian "haus" has revealed, particularly through the patient labors of Lohmann, an elaborateness that puts it along side the sting of the honey-bee as a puzzle to the student of adaptations. For one thing the apparatus turns out to be a strainer of the most exquisite fineness.

One of the most interesting results of Salensky's extensive studies on the anatomy of appendicularians is that the heart of these animals is far more simple than was supposed, and that it is probably homologous with the procardial organ of the ascidian proper.

Branching of the nuclei of some of the ectodermal secretory cells of Oikopleura occurs to such an extent that it may well attract the attention of those interested in general problems of cell structure and activity.

Metcalf's findings relative to the fusion or intergradation of nervous and glandular tissues in the neuro-glandular complex of several ascidians is noteworthy. Of general significance also may

be mentioned the tendency to multiplication of ganglionic outgrowths observed by Metcalf in Salpa.

4. **Embryology.**— Knowledge of tunicate development has progressed in numerous ways during the decade. According to my judgment two of these are particularly significant to the general biologist. They pertain to the very early embryonic life and to the multiplication of branchial stigmata. Among the investigations of the early embryo those by Conklin easily hold first place. To the embryologist, one set of facts brought out by Conklin stands with special prominence in the midst of many that are important. These relate to the question of organization in the unsegmented egg. Conklin's figures seem to furnish strong support for his statement that "it is doubtful whether any other case of cytoplasmic localization hitherto reported is more remarkable than that which has been described in the preceding pages for the ascidian egg."

Important as are these particular truths of ascidian development emphasized by Conklin's observations, there are other aspects of his work which appeal particularly to the general zoologist. In a résumé of what is known about cytoplasmic localization the author says:— "The annelids do not approach the chordates nor the echinoderms in the earliest stages of localization any more closely than in their cleavage stages or later development. *In short there is no convergence toward a common type of localization as one goes back to earlier and earlier stages in the ontogeny.*" In another connection Conklin points out that the pigmentation of the ovum which has served him so admirably in making out the "specification" in the development of Cynthia "may differ most remarkably in different genera of ascidians"; and that "the same may also be said of the yolk." Of the pigment he says, "this inert substance is not in itself of differential value, but it lies in a definite region of the egg and probably in a particular kind of protoplasm." The general zoologist, particularly the taxonomist, must inquire in the presence of these facts, Where is this sort of discovery going to lead us? If, viewing developing animals broadly, we find types of presegmental localization or in ordinary terms, types of *egg structure* that do not converge to a common type; and if eggs from genera so closely related as Cyn-

thia[1] and Molgula differ remarkably in "kinds of protoplasm," does it mean that by and by we are going to find specific characters in the eggs of aminals as well as in their adult condition? For my own part, speaking as a systematist, I am fully prepared to accept the full consequences of just this outcome. Furthermore I see something of the reach of such consequences.

The fact about the development of branchial stigmata which seems to me second in significance only to cytoplasmic localization, is that the origin of the epithelium of new stigmata is always dependent on that of preceding ones. The general question of how repetitive parts arise is basal. These results on the branchial stigmata of ascidians seem to be decisive so far. Selys-Longchamps, Dumas and Julin are specially to be mentioned in these investigations.

The somewhat bizarre notions which gained currency some time ago about the origin and fate of the follicle cells of the ascidian ovum seem to have been pretty nearly disposed of during the decade, thanks to Floderus, Bancroft, Todaro, and Korotneff.

Origin of the heart from the ectoderm is affirmed by Salensky. He treats this along with other instances of ontogenic origin of ascidian parts in defiance of rigid germ layer tenets, under the term "heteroblasty." This general subject, important as it is, has received no thorough investigation during the decade.

The regular succession of generations of ascidiozoids in the Botryllus colony observed by Pizon and Bancroft is a significant enlargement of our knowledge of development on the plane of organic animal societies.

5. **Physiology.**— Studies of the degeneration and rejuvenation of colonies of compound ascidians (Pizon, Caullery, Bancroft) have yielded significant results. For one thing the dying down of the colonies seems to be at least partly a normal senescent phenomenon and not due to the direct influence of environment.

Colonial as contrasted with zooidal individuality is suggested particularly by studies on growth and blood circulation in the Botryllus colony. The interesting fact is brought out by Ban-

[1] Attention should be called to the fact that if Conklin's eggs were from the *Halocynthia partita* of Verrill. he was really dealing with a Styela and not with the genus Cynthia at all.

croft that the ectodermal ampullæ in the test substance of the Botryllus colony are rhythmically contractile and have a regular circulatory office. There is coordinated activity among large numbers of ampullæ in the same colony and this seems to be without the intermediation of the nervous system.

The unique form of tunicate heart action has continued to attract attention. The most comprehensive study of it is by L. Schultze on Salpa. "The heart of Salpa is an example of purely muscular self-regulation in a highly coordinated mechanism of motion." This sentence summarizes Schultze's positive results. Neither cerebral influence nor blood pressure play a causal part in the phenomena. Of similar general import Bancroft and Esterly find proof of polarization through its own activity in the heart of Ciona. On the other hand Magnus, Hunter and Fröhlich bring forward rather strong evidence of the dependence of heart action in Ciona on ganglia and to some extent on the brain.

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NOTES AND LITERATURE

GENERAL BIOLOGY

The Agassiz Centennial.— On May twenty-seventh the one hundredth anniversary of the birth of Louis Agassiz was observed in Sanders Theatre, Cambridge, by a public reunion of his pupils. President Dana of the Cambridge Historical Society made the opening remarks and presented Colonel Thomas Wentworth Higginson, the chairman of the meeting. Letters were read from Professors Dall, Verrill, Wilder, Holland, Brooks, Ehlers and Bouvier. Professor A. L. Lowell spoke of the coming of Agassiz to America at the invitation of the Lowell Institute of Boston. Professors Niles and Gray told of his influence upon his pupils and over the community. Two poems, "The fiftieth birthday of Agassiz" by Longfellow, and "The prayer of Agassiz" by Whittier were read by Professor Winter. The meeting closed with the short address by President Eliot which is printed in full in this number of the *Naturalist.*

Commemorative meetings were held in other places. At Barnes Hall, Cornell University, Professor Burt G. Wilder delivered an address on "What we owe to Agassiz," a portion of which is printed in the *Cornell Era* (vol. 39, pp. 441–446).

To the younger generation of scientists the attractive and impressive personality of Agassiz belongs essentially with the past. Some children are still led by an inborn love of nature to hunt the fields and ponds for strange creatures, and to bring home small fishes to the watering trough. Sometimes they are later found at a school of medicine where parental warnings fail to keep their interests within the presumably lucrative bounds. Occasionally while quite young they are entrusted with important scientific work,— but they do not become naturalists.

It is said that Agassiz's first essay in natural history was a catalogue of the plants of the Jura Vaudois; later he was professor both of geology and zoology. "The plan of creation" was not too large a subject for a lecture course. The laboratory and the teacher's desk were attractive as a means to make known what was gathered from the sea or observed on the mountains. At the inauguration of Cornell University in 1868 Agassiz said,— "I am full of recollections of the Rocky Mountains. I wish this were a fitting time and place to speak of nature, its beauties

and its instruction, for I should know then that I was upon my own ground." Nature was studied in a large way, and directly, without the intervention of collectors and preparators. In this far-reaching knowledge and discerning love of nature, unlimited by class or kingdom, Agassiz was a naturalist. But the minute, laboratory method of study which he advocated has ended the succession. Given fishes to *study* and one is busy for life; the interest in glaciers, flowers, and the plan of creation are lost in the intensive activity of the ichthyologist. The love of nature may indeed remain, but the knowledge of nature must be narrow or superficial; and the scientist of to-day is far removed from the naturalist of the past.

To retain something of the broader interest has been the purpose of this journal. Through its pages many of Agassiz's pupils have circulated the teachings of natural history, and to spread such knowledge was their master's delight. The number for March 1898, contains seven articles commemorating the beginning of Agassiz's Harvard professorship which "marked a new era in the history of zoology in America." To these tributes it is a pleasure to add that of President Eliot.

The Preservation of Native Animals and Plants.— Both in America and in Europe the destructive effects of the growth of cities and spread of monotonously cultivated areas are receiving earnest attention. There is also widespread protest against every form of wilful and needless destruction of animals or plants. Those who feel some resentment that the portion of the world in which they live is not as attractive as their grandfathers found it, will find signs of better times in current literature and activities, a few of which will be cited. Beginning with the preservation of mammals we quote as follows from H. H. Johnston, in *Nature* (1907, vol. 76, p. 34).

"So far back as 1890 a movement began in Great Britain in favour of preserving wild life in lands under British control rather than allowing it to be exterminated by ruthless shooters. To some extent this movement was inspired from the United States. The creation of the National Park of the Yellowstone district, which was to lead to the formation of a 'paradise' for the nearly extinct bison, bears, prongbuck, deer, and wolves of central North America, suggested to several sportsmen-naturalists of Great Britain similar preserves in tropical lands, especially in Africa. Of course, long antecedent to that, British naturalists had at last induced the State to legislate for the preservation of the scanty remains of the British fauna, and although our measures

in this respect are still woefully inadequate, and a limited and old-fashioned class is allowed to push certain forms of sport at the expense of the wild fauna of these islands, still we have saved much; and in some districts of Great Britain birds and the smaller mammals really form constant and charming features in the landscape.

"The great invasion of Africa which began in earnest in 1890, directed public attention to the coincident slaughter of big game which everywhere accompanied the pioneering parties of the British. Just as Great Britain.... has gone far beyond any other nationality in the destruction of wild beasts and birds, her people are now foremost (though the United States is running almost neck and neck) in the world-movement for the preservation from extinction of all but the most harmful animals. We cannot be contented aesthetically with beef, mutton, poultry and pheasants, but to complete the interest of our lives we must have beautiful wild things around us to admire and study; there must be a place in our society for the rhinoceros, the lion, tiger, and even the wolf."

In southern New England only the weaker mammals remain. Attempts are made to introduce woodchucks, muskrats, and squirrels in the city parks where it is a crime to molest them, but in the country districts where these animals are much more attractive, bounties are offered for their destruction in case their skins are not sufficient lure. The wearing of furs is largely needless,— the lack of "buffalo robes" is not felt though the loss of the bison remains. A protest against the wearing of furs has recently appeared in *Life*.

The greatest interest in animal preservation attaches to the birds. Present legislation does not prevent the unnecessary decrease of many kinds. Brewster notes that "the Solitary Sandpiper is one of the few waders that have not diminished perceptibly in numbers within the past thirty years" (*The Birds of the Cambridge Region*, p. 165). There seems to be no good reason why the pleasure of a few in shooting shore birds should continue at the expense of many.

The scientific value of egg and skin collecting is relatively slight. *Bird Lore* and *The Condor* have recently been at odds whether oology is a science at all. It is clear that the deepest science is often the least destructive to nature. Embryologists have learned the development of birds by studying domesticated forms,— the chick more than all others together. The position of birds in the animal series is and will be based upon thorough anatomical and physiological study of these forms. Under the name of science, however, many a superficial collector has sought refuge.

In a neighboring town a beautiful museum has been erected, devoted exclusively to birds. It contains a specimen of the great auk. For scientific purposes, a synoptic collection of equal size, similar to that in Cambridge planned by Agassiz, would be of more value to the town. In the same village and quite as attractive, there is a long low barn with overhanging eaves under which there are some forty populous nests of the eave swallow. The owner has left out a few panes of glass from an upper window so that barn swallows are there also, and the two forms of birds can scarcely be confused after a visit to his place. The town ought to recognize its indebtedness to such a citizen as it does to the donor of a museum. How desirable he is as compared with the owner of the last large colony in the Cambridge region! Of that colony Brewster records that in 1869 "there were sixty or seventy occupied nests strung in a long row along the western side of a large barn. The owner of the place destroyed them all soon afterwards and they did not return. He objected to the presence of the swallows because their droppings disfigured his barn." Mr. Brewster's volume contains many such unpleasant memoranda. A great gray owl had the misfortune to visit Cambridge where it was observed by a woman who asked a certain Mr. Malone to shoot it. "It stared at him fixedly with its yellow eyes wide open, but showed no alarm at his presence although he went almost directly under the branch on which it was sitting. After watching it for a few moments, he fired at it but missed. At his second shot the bird flew across the paddock and alighted on the end of a spruce limb. It proved to be badly wounded and soon fluttered down to the ground where it stood on the defensive, presenting so menacing an appearance that he did not venture to touch it for several minutes. It died a few hours later."

A bill to protect these birds failed to be passed in Massachusetts but justice demands that they should be the property of all and not of the first selfish observer. All forms of native animals which are readily seen should be protected; if they are required in large numbers they should be reared for the purpose. The first remark of a systematist who was asked to identify a lot of turtles for dissection was,— "Some place is being depopulated of its tortoises!" Children should be taught to rear insects rather than to destroy all available Lepidoptera. In these days of inexpensive and quite accurate pictures, collections are not necessary for identification, and science is advanced by detailed studies of common forms,— the brown-tail caterpillar and the Colorado potato beetle — rather than by collecting luna and imperial moths.

Similar problems confront the botanist. Just as boys gather eggs and butterflies, girls make large bouquets of wild flowers and are often encouraged by the advice that 'the more they pick, the more there will be.' There is a mercenary motive also, for the arbutus, fringed gentian and sabbatia among others are tied in compact bunches and sold in the cities,— a practice which might properly be prevented by law. The mayflower is so protected in Connecticut. To prevent thoughtless and wilful destruction there are at least two important organizations, *The Wild Flower Preservation Society of America*, and the *Society for the Protection of Native Plants*. The officers of the latter are among the most eminent botanists of New England and its membership is about seventeen hundred. The *Naturalist* has received copies of its leaflets which are widely circulated without charge. They urge that the roots of plants shall not be disturbed, and protest particularly against the destruction of arbutus, gentians, Christmas evergreens,— mountain laurel and ground pine, various orchids, and all the rarer flowers, even by botanists. For decorative purposes daisies and buttercups may be gathered indiscriminately. Asters and goldenrod may be taken freely, except that flowers by the roadside should be left for general enjoyment. They quote Ruskin,— "Flowers seem intended for the solace of ordinary humanity; children love them; quiet contented ordinary people love them as they grow; luxurious and disorderly people rejoice in them gathered...."

All of these efforts for the preservation of native plants and animals indicate the progress of natural science. They are based, not upon sentiment, but upon a more intelligent appreciation of nature; and they deserve success.

F. T. L.

ZOOLOGY

The Curious Mating Habit of the Fly *Rivellia boscii*.— The following observations were made near Toronto in the latter part of June. The flies were found in bright sunlight about noon on leaves of bushes and flowers in a garden border. The behavior of four pairs only will be described for though other pairs were seen going through similar movements, only four were watched from their first meeting until separation. In all cases the female runs about on the leaves in small circles and spirals varied by an occasional straight course. The wings are extended and moved slowly up and down; at intervals

she stops for a second or two and then goes on. The male who is much smaller follows closely and when the pace admits touches her abdomen with his proboscis or with one of his anterior pair of legs. Sooner or later he mounts the back of the female, the penis is extended and taps the abdomen of the female two or three times when the latter also becomes extended and copulation begins. This extension of the female's abdomen is necessary to connection and seems purely automatic, for it invariably occurs even when her previous and subsequent actions show that the male's attentions are not acceptable.

Pair I. In copula the wings keep in constant motion, while at intervals of three or four minutes a period of greater excitement arrives during which the wings of both are moved more rapidly and their probosces are alternately extended and retracted. After a few seconds of this excitement a droplet of colorless fluid appears at the end of the proboscis of the male and rapidly increases in size until from one-half to two-thirds of a millimeter in diameter. This is not a bubble but a solid globule. The male now raises his proboscis as high as possible and lurching forward with his body, brings it down with a sweep and transfers the globule to the proboscis of the female which she elevates to receive it. The movement is rapid and very deft. Under movements of the female's proboscis the globule now dwindles and disappears; evidently she eats it. This transference of a globule is repeated many times before the pair separate. The male maintains his position chiefly by grasping the abdomen of the female with the second pair of legs, the first pair resting either on abdomen or thorax.

Pair II. The male succeeded several times in mounting but each time was dislodged by the female by movements of her legs and whole body. Male number two appeared on the scene and mounting was allowed to remain. Male number one endeavored to displace him but failing several times, soon went off. After the first globule had been handed over by male number two he dismounted of his own accord and went off.

Pair III. After handing over the globule the male would dismount of his own choice and run in circles around the female who remained almost stationary. After three or four minutes he would mount, the globule would appear at once and be handed over as usual. This occurred many times in succession.

Pair IV. The globule would appear as usual but with less excitement on the part of the male, as shown by sluggish movements or none at all, of wings, legs, and proboscis. After appearing and increasing to the usual size it would decrease, evidently being consumed by

the male himself. This occurred five times in succession. At intervals the female struggled to rid herself of him but did not succeed. The sixth time that the globule appeared was immediately after one of these struggles; this time the globule was handed over but the male dismounted at once of his own accord and went off.

The habit itself is curious enough, but no less interesting are the variations noted and the decided imperfection of instinct in the male of pair number four. The apparent choice exerted by the female of pair number two, and the whole behavior of the pairs gave an impression that could not be harmonized with any theory of insect behavior that considered insects pure automata.

Another point of interest is the possible connection between these globules and those referred to by J. M. Aldrich and L. A. Turley in an article entitled "A balloon-making fly" (*Amer. Nat.*, 1899, vol. 33, pp. 809–812). The balloons are described as hollow, elliptical structures "composed entirely of a single layer of minute bubbles," and it is said that they are probably produced by the anal organs as in the leaf-hoppers "but no positive observations on this point could be made." The authors do not state plainly that the bubbles contain air; in the present case, however, there are certainly no bubbles, but solid droplets probably of salivary secretion.

The behavior of these flies suggests that of the pigeon as described by Dr. E. H. Harper (*Amer. Journ. of Anat.*, 1904, vol. 3, p. 354). He says,— "There is an act which regularly precedes copulation, in which there is an apparent regurgitation of some secretion by the male which is taken from his throat by the bill of the female, in somewhat the same manner as the young birds take their food. It is a less violent manifestation than the feeding of the young however. It is easy to see that here may be one of the sources of indirect stimulation to the female reproductive organs." (Compare with the stroking of the salamander recorded in the following note.)

Specimens of the fly were preserved and through the kindness of Dr. L. O. Howard, identified as *Rivellia boscii* (Desv.).

W. H. Piersol.

The Spermatophores of Salamandra.— In connection with Dr. Smith's account of the spermatophores of Amblystoma published in the last number of the *Naturalist*, the recent paper by W. Docters van Leeuwen is of special interest (Über die Aufnahme der Spermatophoren bei *Salamandra maculosa* Laur., *Zool. Anz.*, 1907, vol. 31, pp. 649–653). The animals observed were in confinement but the

conditions were believed to be natural. At twilight the salamanders come out from the mossy logs, and the male having found a mate crawls under her body, working his way forward. His front legs are swung around those of the female and he strokes the under side of her head with his nose. After a time a spermatophore is deposited on the moss. It is a pyramidal structure 8–10 mm. high and 4–6 mm. wide, sharply pointed with the apex upward. After its deposition the male swings his body 90 degrees to one side, but retains his grasp, and his head remains beneath that of the female. The cloaca of the female is thus brought over the spermatophore which is taken up before the pair separates. Mating occurs from July to September or October, and the spermatophores are always deposited on land. The eggs are fertilized and in the following spring or early summer the young are laid. A new set of eggs is then mature and ready for fertilization.

F. T. L.

Stone-gathering Fishes. — In the *American Naturalist* for May (pages 323–327 of the current volume), Dr. Alfred W. G. Wilson has given important information and excellent illustrations of so-called "Chubs' Nests." Although, as stated in a foot-note, no account of these nests is included in my article on "Parental care among fresh water fishes," it is recorded (p. 436) that several American cyprinids "also take care of their eggs, especially the Horned Dace (*Semotilus atromaculatus*), the Black-headed Dace (*Pimephales promelas*), and the Stone-roller (*Campostoma anomalum*)." I did not give any further information for two reasons; the data in the books were unsatisfactory, and Professor Jacob Reighard had informed me that he would soon publish an account of the habits of these fishes.

The evidence as to the exact species that heaps the stones in question needs confirmation. Dr. C. C. Abbott, in "A naturalist's rambles about home" (1884, p. 408) positively declares that *Semotilus corporalis* (called by him *bullaris*) "differs materially from the birds and even many fish" in that "it does not concern itself with the care of its offspring. Once the eggs are laid upon their bed of sand, all care as to their future vanishes"; he says nothing about the oviposition of *Semotilus atromaculatus* noticed on page 409 and called by him *S. corporalis* (p. 479).

Semotilus atromaculatus occurs in Canada as well as *S. corporalis*; it is known not only as Dace but as Chub, both English terms being applied to this American fish which is no nearer one than the other.

The question thus arises whether the fish which prepared the chubs' nests observed by Dr. Wilson was *Semotilus corporalis*[1] or *S. atromaculatus*; the former has been declared not to be a nest-maker and the latter is known to be such.

Our own common catfish does indeed carry "stones *away* from its nest" but the following instance of the contrary habit has been described in my article (p. 453). The Australian catfish (*Arius australis*) according to Professor Richard Semon resorts to flat, sandy, and stony parts of the river under a rapidly passing current to spawn. "When depositing its eggs and building its nest the fish goes to work in the following way. It begins by preparing a bedding about half a yard in area, consisting of gravel and small pebbles among which it deposits the spawn which is instantly milted by the male. After this it covers the eggs by several layers of bigger stones, thereby preventing them from being washed away by the stream, or carried off by water birds .... or by marauding little fishes. The material for this defensive structure is derived from the above mentioned ring (surrounding the nest) which thereby becomes devoid of all stones and gleams brightly in its smooth garb of white sand. It is wonderful to observe the accuracy of the fish's handiwork and the perfect circle described by the ring. So far as I could see the fish moved the bigger stones by pushing them along with its tail. The whole affair shows a very clever arrangement, the eggs being well shielded from enemies, well ventilated by the current, and even protected against being mud-stifled (save in case of a downright flood)."

I may add that the earliest detailed notice of a stone-gathering cyprinid that I know of, was communicated by Dr. W. H. Gregg to the *American Naturalist* in 1879 (vol. 13, p. 321); the fish was identified by him as *Rhinichthys atronasus*.

THEODORE GILL

[1] In Dr. Wilson's paper (p. 327) *Semnotilus corporalis* Mitchell should read *Semotilus corporalis* (Mitchill).

BOTANY

The Search for Mutations.— Few are inclined to doubt the reality of the mutations observed by DeVries in the cultivated evening primrose, but many have questioned whether these changes occur at all frequently in nature. The search for them has been active since the publication of *Die Mutationstheorie*.

Cockyane (*New Phyt.*, 6: 43–46, 1907) describes pink, rose pink, and even bright rose forms of *Leptospermum scoparium*. So far as he was able to determine these color varieties must have originated in single individuals by discontinuous variation.

Cockerell (*Bot. Gaz.*, 43: 283–284, 1907) reports that near Boulder, Colorado, *Euphorbia corollata* has only four glands instead of the five normal to the species. No plants with five were seen.

Rehder (*Bot. Gaz.*, 43: 281–282, 1907) records the discovery in British Columbia of a fine specimen of *Rhododendron albiflorum* with double flowers. There was petalody of the stamens and carpels, with a considerable increase in their number. Only a single, imperfectly developed anther was found. Wild rhododendrons with double flowers are rare; in the Alps *R. ferrugineum* with double flowers has been observed at least twice.

Focke (*Abh. naturw. Ver., Bremen*, 19: 74–75, 1907) announces the gradual change of *Datura tatula* to *D. stramonium*. The offspring of typical *D. tatula* became weaker and paler from year to year until finally vigorous *D. stramonium* plants were produced from the seed of the weaklings. Since the methods of culture and pollination are not given in detail these results cannot be accepted without verification. The author records also a number of variations which some might class as mutations.

In connection with the recent discussions of geographic isolation in the *American Naturalist*, the observations of Schaffner are of interest (*Ohio Naturalist*, 7: 41–44, 1906). He discovered a new variety of *Verbena stricta* growing in Clay County, Kansas, distributed over somewhat more than a square mile of territory and represented by thousands of specimens. The new form is characterized by a pinkish white corolla, and among many thousands of specimens no transitional forms were found. In some spots the new form was more abundant; in others the parent species predominated; and elsewhere the two

forms were about equally represented. Schaffner considered this unquestionably a mutation, and points to the significance of the fact that it has been able to persist and spread without any geographic isolation whatever.

The observations of Druery (*Journ. Roy. Hort. Soc.*, 31: 77–83, 1906) on the wild sports of British ferns are also pertinent. He records a case in which the cristate form of *Pteris aquilina* was found covering an area of several acres, having apparently superseded the normal form in this one locality. Druery has devoted much attention to the collection and cultivation of the wild sports of British ferns. The British Isles are particularly rich in these sports of extremely divergent character and often of great beauty. About 1200 wild forms have been catalogued as distinct although only some 40 species are listed for the flora, and the majority of these have sported only rarely. Most of the ornamental forms cultivated in gardens have originated in nature and not under the influence of cultural conditions. The spores collected from wild plants yield the anomaly in its full development, or in three generations at the most, so that there can be no suggestion of a gradual development by the selection of minute variations. In nature the aberrant and the typical forms are found growing together but no intermediates are to be seen.

Shull (*Science*, n. s. 25: 590–591, 1907) has been occupied for some time with pedigree experiments on the common shepherd's purse and now announces results of great interest based upon the examination of over 20,000 pedigreed individuals. Four elementary forms have been discovered which breed true when self fertilized or crossed within the limits of the same elementary species. Upon crossing, these forms hybridize in strictly Mendelian fashion. Other atypic forms which appeared in the cultures breed true to their characteristics and do not show Mendelian segregation, but Dr. Shull is unwilling to advance them as mutants since they were not produced from the seed of guarded flowers. Shull (*loc. cit.*) and Transeau (*Science*, n. s. 25: 269–270, 1907) both point out the significance of Mendelian hybridization in the persistence and migration of a newly arisen type. The recessive form is at no disadvantage from crossing with the parent in these cases but sometimes probably has the advantage.

Zoologists are more cautious than botanists in accepting the mutation theory. Whitman has recently criticized it (*Bull. Wisc. Nat. Hist. Soc.*, n. s. 5: 6–14, 1907). Duerden (*Rec. Albany Mus.*, 2: 65–96, 1907) in his studies of the genesis of color patterns in tortoises concludes that the color patterns must have arisen by gradual modification and not by sudden transformation. Ortmann (*Mem. of the*

Carnegie Mus., 2 :343–524, 1906) studied the crawfishes of Pennsylvania and states that "anything that looks like a 'mutation' in de Vries's sense is entirely unknown." Closely allied species either have distinct geographical distributions or if found in one locality they prefer different habitats.

W. D. Tower is of the opinion that "the evolution of the genus Leptinotarsa and of animals in general has been continuous and direct, developing new species in migrating races by direct response to the conditions of existence" (*Carnegie Inst.*, Publ. 48). He states that "there is not at present evidence to show the origin of any heritable variations in the soma"; and that "in these beetles we can get new permanent variations by stimulating the germ cells and in no other way." Such an inheritable character he produced artificially by subjecting adult beetles to abnormal conditions of temperature, moisture, and barometric pressure. The eggs produced and developing under these conditions give rise to new forms which breed true even under normal conditions. But the parent beetles when restored to normal conditions produce offspring of the original type. The new forms are therefore believed to be due to influences of environmental conditions on the germ plasm. F. E. Lutz of the Cold Spring Harbor Station has reviewed Dr. Tower's work from the mutationist's point of view, as follows (*Canadian Ent.*, 39: 176–179, 1907),—

"The author maintains that 'mutation is not a special kind of variability different from that of ordinary fluctuating variation, but it is a part of the normal variability, and the direct response of the germ plasm to stimuli.' He finds that 'extreme variates' are rare, occurring only once in 6,000 cases; and they *breed true*, a thing which ordinary variates do not do. This is my idea of a mutant.... The fact is, Tower has given us one of the strongest arguments for the importance of mutations that has ever been presented. He says,— 'The breeding 'mutants' in our gardens and laboratories cannot tell us how they would succeed in nature; my experience with these beetles is that they fare badly, and, as far as I can discover, that they play a minor role in the evolution of species.' However, he had already stated that not only did *pallida*, one of the 'mutants,' breed absolutely true for six generations in the laboratory with 'no tendency to revert to the parental species' (*decemlineata*), but that from 14 males and 15 females allowed to shift for themselves in nature, 1,580 *pallida* offspring of the 6th generation were found, and he 'felt that further experiment with this form unconfined in nature was neither safe nor desirable, and exterminated the entire lot.' It is true that 29 *pallida* are more than he ever found in nature at one time and place, but he did find 6 at Clifton,

Ohio, and he noted that occasionally, as at Cabin John Bridge, Md., in 1900, sports are relatively very abundant.... If I had been so fortunate as to obtain his results, I would have drawn quite the opposite conclusions, and would have supported the mutation theory most loyally...."

Aigner-Abafi (*Ann. Hist.-Nat. Mus. Nat. Hung.*, 4: 484–531, 1906) describes aberrations or varieties of 113 forms of Lepidoptera, many of which are figured. He aims to include only such as may be of interest to the student of evolution, but offers no suggestions as to their phylogeny which, he believes, should follow experimental researches. He considers that a knowledge of these forms collected in nature will be of great interest in connection with their production by experimental means.

Melanism has received particular attention among mutationists. Porritt (*Rep. Brit. Ass.*, 76: 316–332, 1907) has given a detailed account of the increase of melanism in Yorkshire Lepidoptera. The author confines himself strictly to recording the facts, some of which seem to support the mutation theory although others do not.

In all these cases it is observed that zoologists are cautious about applying the term *mutant* to variations found in nature. Although the teratological studies so popular a few years ago have gained a new significance through the discoveries of De Vries, real progress lies only in the cultivation of these aberrant forms and the recording of their behavior in successive generations under guarded conditions.

J. A. Harris.

Biology in the Journal of Agricultural Science.— Although the real progress of science cannot be properly estimated by the counting of titles of journals, some notion of the interest which is being shown in scientific matters and of the degree to which specialization has extended may be had from this very source. The appearance of the new *Journal of Agricultural Science* indicates that another field of research has become enlarged, and that this division of applied science acquires a more direct means of spreading its benefits.

The purpose of the journal is to afford a "general channel for the publication and discussion of papers bearing on agriculture." Papers on zoology, botany, bacteriology, chemistry physics or geology are accepted if they have a bearing upon the definitely scientific problems of agriculture, but no papers dealing with matters of an ordinary commercial or farming character as distinct from agricultural science are to be admitted. The first six numbers of the journal, fine specimens of the product of the Cambridge press, are now at hand.

The name of W. Bateson on the editorial staff is an assurance that the pages will contain much of interest to students of Mendelism. As a matter of fact, of the forty-seven signed papers ten are devoted mainly to discussions of this new field of experimental work. Biffin has a paper on Mendel's laws of inheritance in wheat breeding, and a supplementary note on the same subject. He discusses also the hybridization of the barleys, the inheritance of sterility in the barleys, and the inheritance of disease resistance. Butler contributes a paper on the bearing of Mendelism on the susceptibility of wheat to rust. The problem of disease resistance is taken up from the histological side by Marryat. Under the title "Hybridization of Cereals," Wilson reports Mendelian studies of oats and barley. Ball presents a note on Mendelian heredity in cotton. Humphries and Biffin discuss the improvement of English wheat. It will be noted that the Mendelian investigations reported are almost exclusively on cereals,— the group of agricultural plants where the results may be expected to have the highest economic importance. An exception is a paper by Wood on the inheritance of horns and face color in sheep.

Other papers of interest to botanists are an article on the influence of pollination in the development of the hop, by Howard; papers on the chemical composition of the swede and mangels, and a paper discussing the law of sequence in the yield of wheat.

A journal of this type should contribute greatly to agricultural progress; moreover it promises to be a mine of facts for the student of pure science.

J. A. HARRIS.

Notes.— *A new flora of Louisiana.* Students interested in the flora of Louisiana must often have regretted the very incomplete publications upon this subject. The "Florula Ludoviciana" of Rafinesque, and the books of Darby and Chapman all fall far short of treating it satisfactorily.

It will be good news that the newly formed Museum Commission of the State of Louisiana, which is charged with the duty of creating a State Museum in New Orleans, contemplates publishing every six months a volume dealing with the history and resources of the state, and that the first volume will be a Flora of Louisiana by Prof. Reginald S. Cocks. This gentleman has given many years of study and active personal research to the work, which would have been published some years since but for an unfortunate fire which destroyed a part of his material.

WILLIAM BEER.

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(*No. 486 was issued June 22, 1907*).